# ESTCP
# Cost and Performance Report

(RC-200720)

## Integrating Archaeological Modeling in DoD Cultural Resource Compliance

October 2012

ENVIRONMENTAL SECURITY
TECHNOLOGY CERTIFICATION PROGRAM

U.S. Department of Defense

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| | | |
|---|---|---|
| 1. REPORT DATE<br>**OCT 2012** | 2. REPORT TYPE | 3. DATES COVERED<br>**00-00-2012 to 00-00-2012** |

| | |
|---|---|
| 4. TITLE AND SUBTITLE<br>**Integrating Archaeological Modeling in DoD Cultural Resource Compliance** | 5a. CONTRACT NUMBER |
| | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**Environmental Security Technology Certification Program (ESTCP),4800 Mark Center Drive, Suite 17D08,Alexandria,VA,22350-3605** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT<br>**unclassified** | b. ABSTRACT<br>**unclassified** | c. THIS PAGE<br>**unclassified** | **Same as Report (SAR)** | **124** | |

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Project: RC-200720

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AAC | Air Armament Center |
| ACC | Air Combat Command |
| ACHP | Advisory Council on Historic Preservation |
| A.D. | *Anno Domini* (Year of our Lord, equivalent to the Christian or Common Era) |
| AFB | Air Force Base |
| AFMC | Air Force Materiel Command |
| AMSL | above mean sea level |
| ANN | artificial neural network |
| APE | area of potential effect |
| B.C. | Before Christ (equivalent to Before the Christian or Common Era) |
| CEMML | Center for Environmental Management on Military Lands |
| CFR | Code of Federal Regulations |
| CRM | cultural resource management |
| DEM | digital elevation model |
| DESCIM | Defense Environmental Security Corporate Information Management |
| DISP | Defense Installations Strategic Plan |
| DoD | U.S. Department of Defense |
| DOT | Department of Transportation |
| EA | environmental assessment |
| EIS | environmental impact statement |
| EOD | explosive ordinance disposal |
| ESTCP | Environmental Security Technology Certification Program |
| FONSI | finding of no significant impact |
| FPO | Federal Preservation Office/Officer |
| GIS | Geographic Information System |
| GMI | Geo-Marine, Inc. |
| GOR | gain over random (statistic) |
| HPA | high probability area |
| HQ | Headquarters |
| ICRMP | Integrated Cultural Resources Management Plan |
| IMCOM | U.S. Army Installation Management Command |
| LBA | Louis Berger & Associates, Incorporated |
| Legacy | Legacy Resource Management Program |
| LIDAR | laser imaging detection and ranging |

## ACRONYMS AND ABBREVIATIONS (continued)

| | |
|---|---|
| MnModel | Minnesota Model |
| MOA | Memorandum of Agreement |
| NAGPRA | Native American Graves Protection and Repatriation Act |
| NEPA | National Environmental Policy Act |
| NHPA | National Historic Preservation Act |
| NRHP | National Register of Historic Places |
| NRCS | National Resources Conservation Service |
| PA | programmatic agreement |
| PTA | Prentice Thomas & Associates, Inc. |
| PUMP | Preferred Upstream Management Practices |
| ROD | Record of Decision |
| S | sensitivity score (statistic) |
| SCR | Saylor Creek Range |
| SDSFIE | Spatial Data Standards for Facilities, Infrastructure, and Environment |
| SERDP | Strategic Environmental Research and Development Program |
| SHPO | State Historic Preservation Office/Officer |
| SRI | Statistical Research, Inc. |
| SRIF | Statistical Research, Inc. Foundation |
| SSURGO | soil survey geographic database |
| STP | shovel test pit |
| TCP | traditional cultural property |
| THPO | Tribal Historic Preservation Office/Officer |
| URS | URS Corporation, Inc. |
| USACE | U.S. Army Corps of Engineers |
| USGS | U.S. Geological Survey |
| UTTR | Utah Test and Training Range |
| UXO | unexploded ordnance |

# ACKNOWLEDGEMENTS

To conduct and complete a lengthy and complicated project like this one requires thanks to many individuals, organizations, and partnerships. Prime among these collaborators are the cultural resource managers and staff of the four U.S. Department of Defense (DoD) installations with whom we worked. We are grateful for their patience, cooperation, and trust. At Eglin Air Force Base (AFB), Mark Stanley and George Cole were our prime contacts. Their long-time research associates and contractors at Prentice Thomas & Associates, Inc. (PTA) provided much needed data and advice. Especially helpful were PTA's Prentice Thomas, Jan Campbell, and James Morehead. Archaeologist Joe Meyer (Center for Environmental Management on Military Lands [CEMML]) and Natural Resource Manager William "Sandy" Pizzolato (CEMML) also met with us at Eglin AFB. At Fort Drum, we wish to thank the following for their assistance: Laurie Rush, Duane Quates, Jaime Marhevsky, and Margaret Schulz. Geoarchaeologist Julieann Van Nest (New York State Museum) and soil scientists Stephen Post (Natural Resources Conservation Service [NRCS], Syracuse) and Amy Norton (NRCS, Lowville) also met with us at Fort Drum. At Saylor Creek Range/Mountain Home AFB, Sheri Robertson was our prime contact with assistance from one of her contractors, geoarchaeologist Charles Frederick (C. Frederick Consulting). At Utah Test and Training Range/Hill AFB, Jaynie Hirschi was our prime contact with assistance from one of her contractors at Far Western Anthropological Research Group, geoarchaeologist D. Craig Young.

Individuals who helped us conceive this work and facilitated our efforts include Martyn Tagg, currently the cultural resource manager for Fort Huachuca. Prior to his current position, Tagg was the cultural resource manager at Headquarters (HQ), Air Force Materiel Command (AFMC) when he and Altschul developed the predictive modeling initiative in 2000; Tagg served as principal investigator on three Legacy projects involving predictive modeling. Likewise, senior level DoD staff have supported and encouraged our efforts for more than a decade. These include present and former DoD Federal and Deputy Federal Preservation Officers (FPO) Maureen Sullivan, Serena Bellew, and Brian Lione, respectively. Support for the premise that archaeological predictive modeling holds enormous potential to streamline environmental compliance also came from Julia King of the Advisory Council on Historic Preservation (ACHP) and other members of the ACHP who invited us to make a presentation in 2010 on the predictive modeling project reported herein in Washington, D.C.

We are thankful for the administrative help provided to us by Jay Newman (U.S. Army Corps of Engineers [USACE], Fort Worth) and the prime contractors—URS Corporation, Inc. (URS) (Steven Tull) and Geo-Marine, Inc. (GMI) (Duane Peter and Michele Wurtz). We are also grateful for the guidance and oversight of our efforts by the staff of the Environmental Security Technology Certification Program (ESTCP), including its Program Manager for Resource Conservation and Climate Change, John Hall. Over the course of these last five years, several key individuals at ESTCP have facilitated our efforts and helped us manage our tasks. Among these individuals are Jonathan Thigpen, Kristen Lau, Pedro Morales, and Badrieh Sheibeh.

Last, but not least, we wish to acknowledge the assistance of members of our own staff who performed a variety of tasks critical for the completion of this research project. SRI Foundation (SRIF) served as prime on this subcontract; Terry Klein oversaw the financial aspects of the five-

year project whereas Carla Van West served as project manager, author, editor, and report compiler. SRIF took the lead in developing programmatic agreements that integrated model results in compliance decisions and producing website guidance content for the project. Statistical Research, Inc. (SRI) took the lead in model development and refinement. SRI's Jeffrey Homburg—a soil scientist and archaeologist—provided essential information for the development of subsurface archaeological models at the installations. SRI archaeologists and Geographic Information System (GIS) specialists Michael Lerch, William Hayden, and Joshua Trampier were responsible for the development of the red flag model prepared for the Saylor Creek Range. We also wish to note that early contributions to this project were made by SRI data analyst Christopher Nagel and SRI GIS specialist Stephen McElroy.

To each and every person who contributed to our success, we say thank you for your help and support. We could not have done it without you.

# EXECUTIVE SUMMARY

## OBJECTIVES OF THE DEMONSTRATION

The U.S. Department of Defense (DoD) is legally required to inventory and evaluate archaeological sites, Native American resources, and other cultural assets on lands it administers. To date, the agency has inventoried less than 40% of its holdings and has another 13.4 million acres to inventory. More than 110,000 sites are recorded, of which more than 20,000 are listed in or eligible for listing in the National Register of Historic Places (NRHP). Many other sites lack determinations of eligibility and must be treated as if they are eligible until their status is confirmed.

DoD must take into account the effects of military actions on thousands of potential historic properties on lands that have not been inventoried and resources that have not been evaluated, so refined technologies are needed to streamline the evaluation process. One particularly effective technology that can be adapted to reduce cost and effort associated with cultural resource management (CRM) requirements is archaeological predictive modeling. To be effective tools for cultural resource management, archaeological predictive models must be operationalized in a database using Geographic Information System (GIS) technology, refined as new data become available, statistically validated to demonstrate their accuracy, and incorporated into programmatic agreements (PAs) that will streamline compliance with the National Historic Preservation Act (NHPA, Section 106) and National Environmental Policy Act (NEPA).

Over the last 30 years, a number of DoD installations, especially those with large land holdings, have developed and used predictive models as planning tools. Few installations, however, have operationalized, refined, and validated their predictive models, and none have incorporated their models into PAs.

The overarching objective of this project was to demonstrate that predictive models of prehistoric archaeological site locations can be sufficiently accurate to serve as the foundation for programmatic approaches to compliance that, when implemented, can achieve greater efficiency and lower costs for administering CRM programs. The specific performance objectives—improving surface, subsurface, and “red flag” predictive models; developing Section 106 PAs; and demonstrating that models integrated into compliance protocols can significantly reduce the level of effort, cost, and number of evaluated sites—were met. Existing models at Fort Drum and Eglin Air Force Base (AFB) were used successfully to demonstrate the technology and their potential. Additional modeling work was conducted at Saylor Creek Range and Utah Test and Training Range; however, these were not formal demonstration sites.

## TECHNOLOGY DESCRIPTION

The project team designed a multiphase process to demonstrate that highly effective archaeological predictive models can be developed to inform management decisions and streamline compliance through the creation of installation-specific PAs. The process began with (1) the collection and evaluation of relevant archeological and environment data, (2) the development of a formal model that can be operationalized with GIS technology, and (3) validation procedures that test the model’s accuracy and determine whether it meets predefined

performance criteria. Once these steps have been taken, modelers may refine the model with new or better data to improve its performance, and then repeat the validation process. With the development of one or more accurate, validated models, the process continues with a fourth phase; the creation of a zonal management model that synthesizes the results of each underlying model. It is this zonal model that DoD managers and stakeholders use to make decisions about inventory and site evaluation protocols in different probability or "sensitivity" zones for finding sites. Through consultation, the final phase is the preparation of a PA that stipulates how Section 106 requirements will be met.

## DEMONSTRATION RESULTS

Using the aforementioned phases, the project team demonstrated that three types of predictive location models could be developed or refined and subsequently integrated into a zonal management model that has been incorporated into draft PAs. The ESTCP project ended before the draft PAs could be finalized and executed, but the project team developed alternate methods to demonstrate the efficacy of using predictive models to manage cultural resources. These alternative methods, which use historic data from each installation on the level of effort and cost of past archaeological inventories, demonstrate considerable time and cost savings when effective models are used.

For Eglin AFB, the project team formalized and tested an existing surface sites model, refined and tested this model, created a model for information-rich habitation sites that would be expensive to mitigate ("red flags"), and created a model for deeply buried or subsurface archaeological sites. The first two models met and exceeded the specified performance criteria for a successful model. The subsurface model could not be tested due to a lack of appropriate data. Team members used the refined surface model, the red flag model, and the subsurface model to create a zonal management model that has been included in a draft PA for managing archaeological resources on Eglin AFB.

For Fort Drum, the project team formalized and tested an existing lowland surface sites model and an existing upland surface sites model, refined and tested both models, and created a model for deeply buried or subsurface archaeological sites. The refined lowland surface model met and exceeded their performance criteria; however, the upland surface model did not. Insufficient data were available to test the subsurface sites model, but a preliminary test using available data suggests that the model is close to meeting the criterion. Team members used the refined surface model and the subsurface model to create a zonal management model that has been included in a draft PA for managing archaeological resources on Fort Drum.

## IMPLEMENTATION ISSUES

Future efforts to create or improve predictive models of archaeological site location now have a tested process for their development, refinement, validation, and integration into the compliance process. Website guidance on how validated and accurate predictive models can be created will serve as the medium of technology transfer for this demonstration project.

Future efforts should consider four implementation issues. First, the weakest link in developing and refining formal, inductive predictive models is the quality of the archaeological and

environmental data. To build models efficiently, relevant archaeological data should be maintained in computerized databases usable by GIS. Similarly, environmental data should be of sufficient accuracy and resolution to facilitate the measurement and correlation of site locations with natural features. Second, to efficiently create and test predictive models, modelers and installation staff need to work together early and often to ensure that key variables are included in both the underlying model and the resulting management model. Third, for predictive models to be incorporated into PAs, installation CRM staff must involve their consulting parties (State Historic Preservation Office [SHPO] staff, Native American groups, and other interested parties) from the beginning of the modeling process and maintain regular contact. Consulting parties will need assurance to maintain their confidence in the value of modeling for finding and protecting sites as well as enhancing knowledge of past cultural systems. Finally, it is critical to view modeling as a process and not an event; models improve with more data, allowing DoD to meet its stewardship and mission goals more efficiently and with better results.

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# 1.0 INTRODUCTION

## 1.1 BACKGROUND

The Department of Defense (DoD) administers lands containing more than 110,000 documented archaeological sites and many times that same number of unrecorded sites (DoD, 2011: Figure 3-2). Each year, the agency spends an average of about $46 million on cultural resources, primarily to comply with the law (DoD, 2011: Figure 1-4). In the past, much of the historic preservation compliance effort has been directed toward identifying archaeological sites and avoiding impacts to them, rather than assessing their eligibility and identifying measures to minimize or mitigate effects. This practice has left military installations with large numbers of unevaluated archaeological sites over vast expanses of their land base. With the shift in military training toward intensive joint operations, there also will be a change from inventory to evaluation of these archeological sites and ultimately to excavation or other forms of mitigation in order to make large areas available for military missions. It is likely that annual expenditures will have to increase substantially unless DoD changes its approach to compliance.

DoD recognizes that a change the approach will be a challenge. Among the policy goals in two recent Defense Installation's Strategic Plans (DISP) are:

- Accurately inventory 100% of archaeological sites, Native American resources, and other cultural assets, and establish quality ratings in the real properties inventory by the end of 2007 (DoD, 2004). This target date was then updated to 2009 (DoD, 2007).
- Develop standards to ensure that the possible presence of archaeological sites, Native American resources, and other cultural assets are modeled, inventoried, and managed in close integration with project and operational planning by the end of fiscal year 2006 (DoD, 2004).
- Manage cultural resource assets efficiently, in full integration with other facilities and project planning activities, and in full compliance with all legal requirements (DoD, 2007).

Although the 2007 deadlines have passed, DoD continues to adhere to these policy goals as it had for most of the previous decade (DoD, 2004). Inventory remains a high priority and a substantial level of effort is dedicated to identifying historic properties. DoD administers about 41,000,000 acres. Of the total, 21,900,000 acres are available for archaeological survey (DoD, 2011). To date, about 8,500,000 acres have been inventoried for cultural resources (DoD, 2011), leaving DoD with another 13,400,000 acres left to survey—a task requiring the expenditure of between $1.5 and $2 billion. To make matters worse, the inventory quality of the already surveyed 8,500,000 acres is suspect (Heilen et al., 2008), with very little having been inspected for traditional cultural properties (TCP) or adequately assessed for buried archaeological sites. Further, many U.S. states have a "life expectancy" for archaeological survey, after which an area must be resurveyed.

As DoD struggles to meet its inventory goal, it must continue to meet its legal obligation to manage cultural resources under agency control. Currently, both the National Environmental

Policy Act (NEPA) and the National Historic Preservation Act (NHPA) compliance tend to be carried out on a project-by-project and historic property-by-historic property basis, which is time-consuming and inefficient both for cultural resources stewardship and for mission planning and implementation. However, there is nothing in the laws or their regulations to prevent a larger-scale programmatic approach to compliance. In fact, the implementing regulations for NHPA Section 106 encourage programmatic approaches. The Section 106 regulations also urge agencies to develop ways to coordinate Section 106- and NEPA-compliance efforts as much as possible, in order to save time and resources.

To take advantage of the flexibility inherent in the Section 106 process and to make sound decisions in the NEPA process, installations need to demonstrate in an objective and replicable manner that they are basing decisions about cultural resource management (CRM) on sound information about the likely nature, distribution, and significance of the archaeological sites within their land base. Archaeological modeling is ideally suited to meeting this need and can form the basis of a rational understanding of this key asset that affects the extent and intensity of operational training. Archaeological models also can reduce the time and money needed to complete the Section 106 process and lower the risk of mission delays.

DoD acknowledges the potential of modeling in the second DISP goal cited. DoD has a long history of sponsoring modeling, particularly locational correlative approaches termed “predictive models.” These models have been used primarily as heuristic devices that provide managers with a sense of where they may encounter cultural resources. By and large, they have not been integrated into NEPA and NHPA compliance, nor have they been used to manage resources. This ESTCP demonstration project, building on 7 years of Legacy-funded work, was designed to validate models and demonstrate their potential for streamlining and economizing compliance and improving asset management. In the process of completing this project, two fundamental facts about modeling archaeological site locations were demonstrated: (1) modeling is a process that must be maintained to be effective, and (2) if maintained, model predictions will improve as more data are incorporated into the model.

## 1.2 OBJECTIVES OF THE DEMONSTRATION

The purpose of the archaeological predictive modeling project was twofold: (1) demonstrate that predictive models of archaeological site locations are sufficiently accurate to serve as the foundation for programmatic approaches to NHPA and NEPA compliance, and (2) develop protocols for validating and refining predictive models and integrating these models into the compliance process. To achieve these goals, the demonstration project had three specific objectives:

1. Develop protocols for validating predictive models of an archaeological site location;
2. Develop protocols for refining the predictive models to meet standards set by regulatory stakeholders; and
3. Develop protocols for integrating refined models into DoD Section 106-compliance and NEPA processes, as well as in early planning processes.

Most of the concerns raised about archaeological predictive modeling are epistemological: how do we know that the model works short of surveying the area? Even then, how do we know that the absence of cultural material means a site is not present as opposed to it being there, but deeply buried? To demonstrate that models work, the regulators must be satisfied that the use of sampling theory is sound, that the field methods produce data of sufficient quality to use in modeling, and that the statistical techniques employed produce accurate predictions. Additionally, it must be demonstrated that the use of GIS technology allows users to characterize the environment in sufficient detail to produce proxy variables of the resources and resource decisions made by prehistoric peoples.

Four installations were initially chosen as demonstration sites: Eglin Air Force Base (AFB), Florida; Fort Drum, New York; Saylor Creek Range (SCR), Idaho; and Utah Test and Training Range (UTTR) (Figure 2). As a group, they were selected to represent a set of installations with contrasting missions, in different regions of the U.S., with distinctive environmental and historical attributes that produced dissimilar cultural histories and archaeological legacies. Each installation, however, incorporated a large area, contained many cultural resources, possessed a well-established CRM program, and had developed (Eglin AFB and Fort Drum) or was interested in developing (UTTR and SCR) some type of predictive model. Midway through our project, however, UTTR and SCR decided that their environmental management interests would be better served if the project team developed other kinds of predictive archaeological models to help them address their CRM needs. Consequently, they withdrew from the demonstration project, as it was originally conceived and approved.[1] Only Eglin AFB and Fort Drum participated in our ESTCP demonstration project on archaeological predictive modeling and the balance of this report pertains to work undertaken at these two installations.

To perform the demonstration, several different types of predictive models were defined: (1) baseline surface models, (2) refined surface models, (3) preliminary subsurface models, (4) “red flag” models, and (5) zonal management models.

Predictive models generally come in two forms: formal predictive models and informal predictive models. *Formal predictive models* consist of explicit statements regarding the definition of variables and their relationship to site location in such a manner that the model can be logically defined within a GIS. *Informal predictive models* lack formal definitions and in their present state require such definitions in order to be operationalized in a GIS, tested, and implemented in a systematic fashion. Installation archaeologists generally have a strong sense where sites will be found, but rarely have these insights been captured in formal models. To be used in the NEPA and NHPA compliance, archaeological insights must be transformed into models that can be replicated and tested for accuracy within agreed upon parameters.

[1] At SCR, the staff requested development of a model of archaeological data quality to help them assess the effectiveness and reliability of previous archaeological survey at the installation. Project Team staff developed a predictive model of archaeological site detection for SCR, which indicates where previous survey is most likely to be unreliable due to poor surface visibility. For UTTR, the staff wanted to be able to predict the location of traditional cultural properties potentially associated with descendant Indian tribes in the region. Project team staff developed an ethnographic land use model predicting the location of historical-period Native American village settlements.

*Baseline surface models* were defined as models that had already been developed by the installation, but needed to be formalized and operationalized in a GIS in order to be tested. For each of the demonstration sites, existing baseline models were formalized as necessary and operationalized in a GIS. To do this, ideas about where archaeological sites tend to be located were transformed into explicit statements about site location that could be codified within a GIS. Formalization and operationalization of baseline models thus allowed those models to be tested with available inventory data.

*Refined surface models* were defined as models that were created as part of the project to improve the predictive capacity and statistical strength of the existing baseline surface models. In order to develop refined surface models of archaeological site location, a number of tasks needed to be performed. These included the development of additional environmental variables in a GIS and evaluation of their potential association with site location; the identification of installation areas and site types with distinctive environmental associations or locational characteristics; the use of current inventory data to develop site and nonsite sample locations for modeling; and the application of advanced statistical modeling techniques. Once developed, refined surface models were validated using existing inventory data and the application of performance metrics defined as part of this project.

*Preliminary subsurface models* were geoarchaeological models developed as part of the project to predict where buried archaeological deposits are possible on an installation. To develop these models, the project geoarchaeologist visited each installation, worked with regional geoscientists, and compiled existing geoarchaeological literature to arrive at an understanding of the kinds of geomorphological contexts where archaeological deposits were likely buried as a result of environmental processes that occurred during the Late Pleistocene and Holocene geological epochs. These understandings were then formalized in a GIS using existing environmental data on soil types and geomorphology. Many of the GIS data used to develop these models were derived from National Resource Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) data that identify soil horizons to a depth of 151 cm.

*Red Flag models* were defined as models of site types that would be especially costly and time-consuming to mitigate should such a site be accidentally discovered during ground disturbing activities (Altschul, 1990). For the purposes of the demonstration, red flag sites were defined as intensively used residential sites. Due to the need for relatively comprehensive site type information, a red flag model was only created for Eglin AFB as site type information was not available for Fort Drum. The red flag model for Eglin AFB was developed in the same manner as the refined surface models, but focusing only on site types associated with intensive residential activity (villages or hamlets, burial sites, and mound sites).

*Zonal management models* were defined as models that combined the predictions of the refined surface model, preliminary subsurface model, and red flag model to indicate the potential for cultural resources in a given area of an installation. To develop a zonal management model, the three models listed above were intersected in a GIS to combine their predictions. Management categories were then developed for all possible combinations (e.g., medium or high subsurface sensitivity; medium or high red flag sensitivity; low, medium, or high surface sensitivity).

## 1.3 REGULATORY DRIVERS

Although other federal statutes apply, the main regulatory drivers of DoD cultural resource compliance are NHPA and NEPA. DoD installations are required to meet the federal requirements under Sections 106 and 110 of NHPA, as well as NEPA and its regulations listed at 40 Code of Federal Regulations (CFR) 1500–1508.

Section 106 of NHPA requires federal agencies (in this case DoD) to take into account the effects of proposed undertakings on historic properties listed in or eligible for listing in the NRHP, and provide the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on the undertaking. The regulation implementing Section 106 (36 CFR Part 800) establishes the process through which federal agencies can meet their responsibilities under this statute. This process consists of four steps, all done in consultation with the Section 106 "consulting parties," as stipulated in the regulation:

1. Determine if the agency's action is an undertaking that falls under the requirements of Section 106, and whether or not the action has the potential to affect historic properties. If the answers are yes, the agency initiates consultation with the appropriate State Historic Preservation Office (SHPO), Tribal Historic Preservation Officer (THPO) (if appropriate) and other consulting parties.
2. Identify the historic properties within a project's area of potential effects (APE) and evaluate eligibility for listing in the National Register of Historic Places (NRHP).
3. Assess the effects of the undertaking. If no historic properties are found in the APE, or if properties are found but the project will not affect the properties, the agency makes a finding of "no historic properties affected." A finding of "no historic properties affected" completes the Section 106 process. If there are historic properties within the APE and the agency determines that its project may affect one or more of these properties, the agency evaluates the nature of these effects. If the project will not diminish those qualities that qualify a property for listing in the NRHP, the agency makes a finding of "no adverse effect." A finding of "no adverse effect" completes the Section 106 process. If the project will diminish these qualities, the agency makes a finding of "adverse effect."
4. Work with the Section 106 consulting parties to resolve adverse effects on historic properties.

Section 110 of NHPA requires federal agencies to assume responsibility for historic properties under their jurisdiction. It also requires agencies to establish a program to identify, evaluate, nominate, and protect these properties. In addition, agencies are to consider the effects of their actions on properties not under their jurisdiction or control. Agencies are also to consult with other agencies, tribes, and the public concerning historic preservation planning activities.

NEPA requires federal agencies to balance federal actions and environmental protection. To comply with NEPA, agency decision-makers must be fully informed about the environmental consequences of their decisions to approve, finance, permit, or license a project. They must also solicit input from and inform the public about the proposed project, the environmental

consequences of the proposed action, and the ultimate agency decision about how the project will proceed. The results of the NEPA decision-making process are disclosed through an environmental document.

The key components of the NEPA process (for those actions that are not categorically excluded or exempt from NEPA compliance) include definition of purpose and need, identification of project alternatives, alternative analysis, and mitigation of adverse impacts. The purpose and need is the statement of the problem to be solved and guides the development of alternatives. The latter are the possible solutions to the problem. Each of the alternatives retained for detailed study is then analyzed in terms its environmental characteristics and setting (referred to as the "affected environment.") Next, the potential impacts to these characteristics and setting are assessed. This analysis includes evaluating impacts on properties listed in or eligible for listing in the NHRP. Once these potential impacts are identified, the agency examines ways to mitigate these impacts. The results of this NEPA environmental review are documented in an environmental impact statement (EIS)/Record of Decision (ROD) or an environmental assessment (EA)/finding of no significant impact (FONSI). After the completion of these documents, the agency implements their selected alternative.

# 2.0 TECHNOLOGY/METHODOLOGY DESCRIPTION

The technology demonstrated by this project was designed to streamline and expedite military cultural resource compliance. This was accomplished through the creation, validation, and refinement of existing predictive models of archaeological site locations at Eglin AFB and Fort Drum. These improved and validated models will ultimately be integrated into the NHPA- and NEPA-compliance programs at each installation through implementation of NHPA Section 106 Programmatic Agreements as further discussed below. The process that was followed during and demonstrated by this project is illustrated in Figure 1.

## 2.1 TECHNOLOGY DESCRIPTION

Archaeological models are formal frameworks that characterize in an objective and replicable manner aspects of past human behavior that often are reflected in the archaeological record. Some archaeological models focus on the location of archaeological sites. These models can be described as location models, which can be derived from theoretical relationships (deductive models) or from empirical data (inductive models). Among the latter are what have become to be known as "predictive models," which use empirical observations from a sample of known sites to predict particular characteristics of suspected sites that have not been found. Most archaeological models developed for military installations over the past 30 years are predictive models of archaeological site location. Though predictive models have been used in CRM since the late 1970s, the first substantial guidance for developing and using these models was a comprehensive text prepared by the Bureau of Land Management in 1988 (Judge and Sebastian, 1988). One of the first major compliance breakthroughs for locational predictive models occurred in 1997 when the Minnesota Department of Transportation (DOT) successfully implemented a statewide model (Minnesota Model [MnModel]) as a planning tool (BRW, Inc., 1996; Hudak et al., 2002).

Even with all the technological advancement, it was not until 2003 that the scientific adequacy of locational modeling, as it has been used by the military, was demonstrated. Based on recommendations from a CRM workshop sponsored by the Strategic Environmental Research Development Program (SERDP) and the Legacy Resource Management Program (Legacy) at Patuxent River Naval Air Station in Lexington Park, Maryland (Legacy #00-101; Briuer et al., 2000), the first of three Legacy projects (#01-167, 03-167, and 06-167) on predictive modeling that led to this ESTCP project were completed.

In a report entitled, *Predictive Modeling in the Military: Similar Goals*, *Divergent Paths*, Altschul and his colleagues (2004; Legacy project #01-167) analyzed models from select DoD installations and provided recommendations for their improvement. This project showed that predictive models—even those using technologies from the late 1970s—have worked surprisingly well. A subsequent Legacy project in 2003 (#03-167) brought together a working team of DoD managers, SHPO representatives, tribal representatives, and modeling experts. The report developed from this workshop was published as *A Workshop on Predictive Modeling & Cultural Resource Management on Military Installations* (Altschul et al., 2005). The team addressed the recommendations from the first Legacy project (#01-167) and determined how the DoD could best utilize modeling in their compliance process. They developed a blueprint by which locational predictive modeling could be incorporated more effectively into DoD cultural

resource compliance and recommended that new kinds of archaeological models be developed that could address the site evaluation process programmatically. Air Combat Command (ACC) Headquarters (HQ) initiated a 2006 Legacy project (#06-167) to implement the innovative blueprint created by the team. The report of this effort is entitled, *Integrating Archaeological Models: Management and Compliance on Military Installations* (Cushman and Sebastian, 2008). Legacy project #06-167, which was the foundation of this ESTCP demonstration project, involved (1) working with two installations (Fort Drum and Eglin AFB) to develop case examples of more effective integration of locational predictive models with compliance and planning, and (2) working with one installation (UTTR) to develop a significance model, which ranks the importance of classes of sites relative to their scientific importance and other heritage values. The Legacy project team, in consultation with installation CRM staff, the New York and Florida SHPOs, and some tribes, has developed a conceptual outline for a program assessment (PA) stipulating how Eglin AFB and Fort Drum would integrate predictive modeling into each installation's Section 106-compliance program. The Legacy team also developed a significance model for the UTTR aimed largely at streamlining NRHP evaluations.

In the last 20 years, the technology of predictive modeling has come of age. Since 1990, five SERDP projects have been funded for predictive modeling—one focused on GIS modeling (#RC-1130) and the other four centered on increasing the detection of archaeological sites on military lands from terrestrial, air, and space remote sensing techniques (RC-1142, RC-1260, RC-1261, and RC-1263). None, however, examined the role of predictive modeling in historic preservation or environmental compliance. In contrast, the Department of Energy sponsored a Preferred Upstream Management Practices (PUMP) grant that focused on the use of predictive models in cultural resources compliance for the oil and gas industry. Statistical Research Inc. Foundation (SRIF) and other team members performed the modeling and compliance study for the New Mexico portion of the PUMP grant (Sebastian et al., 2005). Perhaps the biggest technological gains have been in the field of information management, particularly GIS. Numerous studies have been conducted (e.g., Aldenderfer and Maschner, 1996; Allen et al., 1990; Mehrer and Westcott, 2006; Wescott and Brandon, 2000), including SERDP (RC-1130) and Legacy projects (Altschul et al., 2004).

The most direct testing of predictive modeling technology used within DoD was performed by HQ Air Force Materiel Command (AFMC) (Altschul et al., 2004). HQ AFMC obtained Legacy funding (Project #01-167) to determine if predictive models created by DoD installations were accurate in light of subsequent archaeological inventory. Using a sensitivity score (S) that measured model performance, researchers demonstrated that DoD predictive models worked, but that they could work much better if a number of issues were addressed (Altschul et al., 2004). These issues, which formed many of the demonstration/validation issues of this ESTCP project, are: (1) military predictive models are rudimentary in nature and would be much better predictors if they incorporated multivariate statistical techniques, (2) military models tend to be limited to predicting surface manifestations and would improve if they incorporated geomorphic variables through which they could predict buried sites, (3) the models would improve if they incorporated validation and refinement components, (4) the models are not being used effectively and creatively in the compliance process, and (5) there is no centralized instruction on predictive modeling available to military installations.

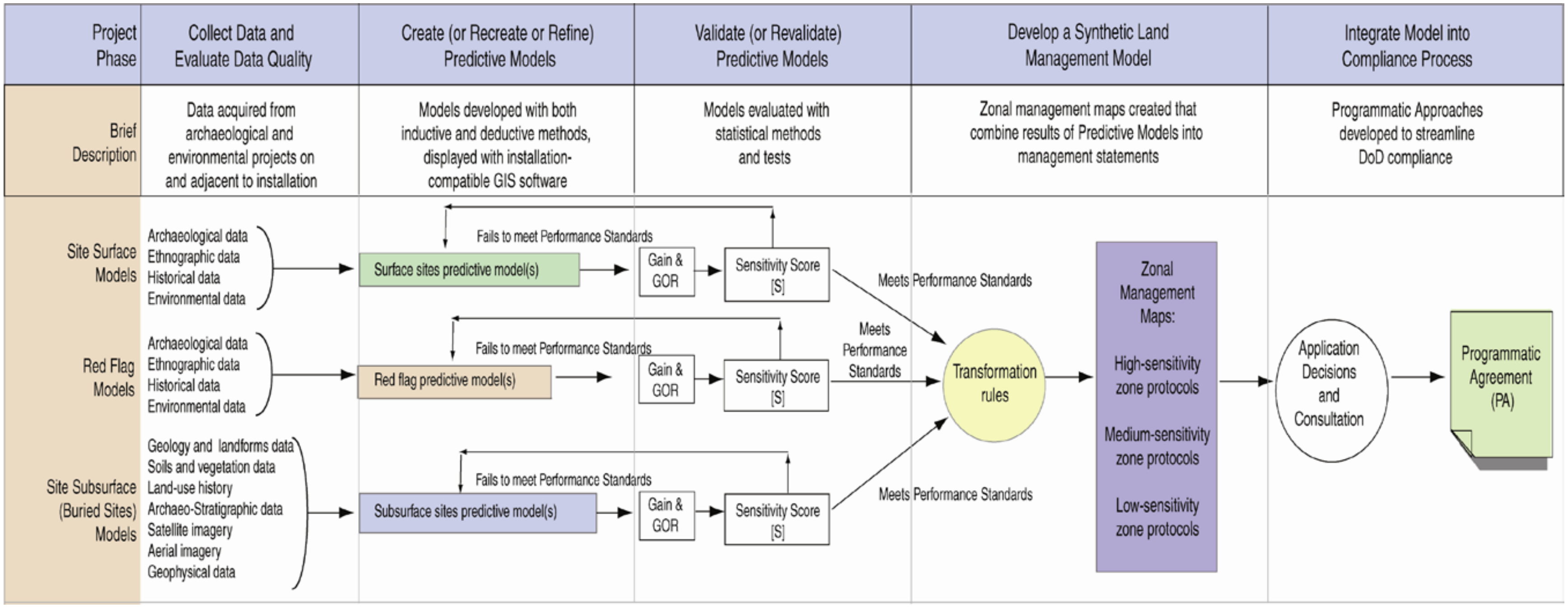


**Figure 1. Flow diagram illustrating the demonstration technology process.**

## 2.2 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY/METHODOLOGY

Predictive modeling provides a framework by which previous knowledge on cultural resources gathered on DoD installations over the last 40 years, at a cost in the tens of millions of dollars can be used by managers to more effectively meet their NHPA- and NEPA-compliance obligations.

Advantages and Strengths:

- Refined models can better assist installations in meeting their management and compliance objectives (see Green et al., 2012:11–12 for a list of 20 specific uses to streamline compliance).
- Advanced statistical techniques for developing refined models (e.g., random forest modeling, neural network models) can be highly useful.
- The strengths and weaknesses of refined models can be readily identified and recommendations for future improvements can be provided.
- CRM staff involvement can ensure the construction of models tailored to the needs of the individual installation.

Disadvantages and Limitations:

- Archeological and environmental data needed to build models and evaluate performance are often lacking or inadequate, thereby requiring a large initial outlay of time and effort to acquire essential information.
- The time and effort coordinating with personnel at military installations during model development, testing, and validation, as well as during the development of draft PA documents, can be labor intensive.
- Heavy workloads and severe scheduling conflicts can prevent CRM staff from making the initial investments needed for predictive modeling to succeed.

# 3.0 PERFORMANCE OBJECTIVES

NEPA and NHPA compliance tends to be carried out on a project-by-project and historic property-by-historic property basis, which is time-consuming and inefficient both for cultural resources stewardship and for mission planning and implementation. The creation, refinement, validation, and implementation of archaeological predictive modeling, however, provides a foundation for programmatic approaches to both NEPA- and NHPA-compliance, allowing installations to reduce or eliminate costly and inefficient case-by-case practices.

The performance objectives for this project were to improve predictive models at selected installations by refining and validating their baseline models and then to demonstrate how these improved and validated models can be used to streamline installation NEPA- and NHPA-compliance responsibilities. The specific performance objectives that were developed for this demonstration and indicate whether or not the success criteria were met are presented in Table 1.

The following are descriptions of each of the performance objectives listed in Table 1 and a summary statement on whether or not the success criteria were met.

Quantitative metrics were used to measure the performance of surface models, subsurface models, and red flag models. They include the sensitivity score (S) (Altschul et al., 2004; Hudak, 2002; http://www.mnmodel.dot.state.nm.us), Gain Statistic (Kvamme, 1988), and the Gain-over-Random (GOR) Statistic (Kvamme, 1992). These statistics, data requirements, and success criteria thresholds are described in detail in Green et al. (2012) and defined in Section 6.0 of this report.

A qualitative metric—a dichotomous yes/no variable—is used to measure the measure whether or not a PA was drafted and/or finalized. The data requirements, success criteria, and results associated with this objective are described in Green et al. (2012).

Quantitative metrics were used to evaluate the performance of the model incorporation into the NHPA Section 106 and NEPA processes. Actual cost and level of effort data obtained from Eglin AFB and Fort Drum were used to create "with model" and "without model" scenarios to simulate how much time and money was and would be saved by using predictive models of archaeological site location to guide management decisions on where and how much archaeological inventory should take place. The metrics, data requirements, success criteria, and results are described in Green et al. (2012).

**Table 1. Performance objectives.**

| Performance Objective | Metric | Data Requirement | Success Criteria | Results |
|---|---|---|---|---|
| Improve archaeological surface predictive models | Large proportion of surface or near-surface archaeological sites in a small proportion of the model area (i.e., S) | Spatially arrayed data on mappable environmental features and archaeological resources from inventory | S≤0.39, when 85% or more of surface and near-surface archaeological sites are located in no more than 33% of the model area | Eglin: Criterion met, S (med/high)=0.17; Gain=0.70; GOR=69.3<br>Fort Drum: Criterion met, S (med/high)=0.30; Gain=0.75; GOR=66.5 |
| Improve archaeological subsurface predictive models | Large proportion of buried archaeological sites in a small proportion of the model area (i.e., S) | Spatially arrayed data on geomorphic surfaces and deeply buried archaeological resources | S≤0.39, when 85% or more of all buried archaeological sites located in no more than 33% of the model area | Eglin: insufficient data<br>Fort Drum: Criterion nearly met, S (med/high)=0.42 |
| Improve archaeological "red flag" predictive models | Large proportion of "red flag" archaeological sites in a small proportion of the model area | Spatially arrayed data on mappable environmental features and archaeological resources from inventory | S≤0.25, when 95% or more of all "red flag" sites located in no more than 24% of the model area | Eglin: Criterion met<br>S (med/high)=0.03<br>Fort Drum: no red flag model |
| Develop Section 106 PA based on modeling | Complete draft(s) and final version of PA | Consultation with installation stakeholders and Section 106 consulting parties to develop the PA | *PA executed and filed with the Advisory Council on Historic Preservation | Draft PAs prepared and under review |
| Streamline NHPA Section 106 and NEPA compliance | Reduce inventory level of effort | Acreage and time (person-days) per survey project | ≥15% reduction in level of effort for inventory | Eglin: Criterion met<br>Time reduced 68%<br>Fort Drum: Criterion met.<br>Time reduced 58% |
| Streamline NHPA Section 106 and NEPA compliance | Reduce inventory cost | Acreage figures and costs per survey project | ≥15% reduction in cost for inventory | Eglin: Criterion met<br>Cost reduced 67%<br>Fort Drum: Criterion met.<br>Cost reduced 66% |
| Streamline NHPA Section 106 and NEPA compliance | Reduce number of evaluated sites | Number of sites per site class that require evaluation | ≥15% reduction in number of sites that must be evaluated and treated | Eglin: Criterion met<br>Sampling reduced number of sites evaluated by 64% |
| Streamline NHPA Section 106 and NEPA compliance | Increase in effective value of compliance process (1 [less effective] to 5 [more effective] ordinal scores) | Survey users before and after models and PA implemented (i.e., compare installation compliance process before and after models in place) | Values of 4 or 5 (the highest satisfaction and value scores) | Eglin, Fort Drum: Survey not conducted |

# 4.0 SITE DESCRIPTIONS

Four installations were initially selected and agreed to participate in this demonstration project. These were: Eglin AFB, Florida; Fort Drum, New York; SCR, Idaho (administered by Mountain Home AFB); and UTTR (administered by Hill AFB) (Figure 2). Selection criteria included military service and mission, geographic distribution, and status of model development. During the course of the demonstration project, UTTR and SCR withdrew from the formal archaeological predictive modeling effort and chose to pursue different modeling objectives (see Appendices D and E in Green et al., 2012). The following sections present site location, site characteristics, and CRM program histories for Fort Drum and Eglin AFB, which then became the focus of the project.

## 4.1 SITE LOCATION AND HISTORY: EGLIN AFB

Eglin AFB is within the AFMC and home to the 96th Air Base Wing. Eglin's Air Armament Center (AAC) plans, directs, and conducts tests and evaluation of armament, navigation, and guidance systems, as well as command and control systems, over a very large test range. Eglin covers approximately 188,300 hectares (465,284 acres) and is unique for its offering of expansive land and water ranges for military training.

### 4.1.1 Location and Site Characteristics

Located in the Florida panhandle, Eglin is bordered by the Yellow River, Shoal River, and Titi Creek to the north, Highway 331 and private lands to the east and northeast, Choctawhatchee Bay and the Gulf of Mexico to the south, and Escambia Bay to the west (Figure 3). Eglin is approximately 84 kilometers (km) (52 miles) east to west and 29 km (18 miles) north to south and is nearly contiguous with the Blackwater River State Forest to the north. The main reservation encompasses portions of Okaloosa, Santa Rosa, and Walton counties along Florida's northwest coast; however, two contiguous training and radar sites are located in Gulf and Bay counties.

### 4.1.2 Culture History

Eglin AFB's human history extends back thousands of years into the early Holocene epoch (Green et al., 2001). Stone tools manufactured and used by nomadic Paleoindian populations (9000–6500 before Christ [B.C.]) are the earliest artifacts recovered. Subsequent populations of Archaic-period (6500–400 B.C.) and Woodland-period (400 B.C.–*Anno Domini* [A.D.] 1050) hunter-gatherers and fishers who visited and later settled along coastal areas, bay shores, river margins, and inland forests subsisted on locally available food resources and participated in regional trade networks active in U.S. Southeast. Food remains, campsites, small hamlets, and diagnostic artifacts including carved steatite bowls, fiber-tempered pottery, exotic stone for stone tools and weapons, and copper items allow archaeologists to reconstruct aspects of Eglin's Archaic-period history. Similarly, settlement forms, burial customs, and specific artifacts that represent regional expressions of the Woodland-period Marksville and Hopewell cultural traditions have helped archaeologists comprehend some of the ways that Eglin-area populations shared behaviors and values with other regions. Evidence for maize horticulture appears for the first time during the Mississippian period (A.D. 1050–1600).

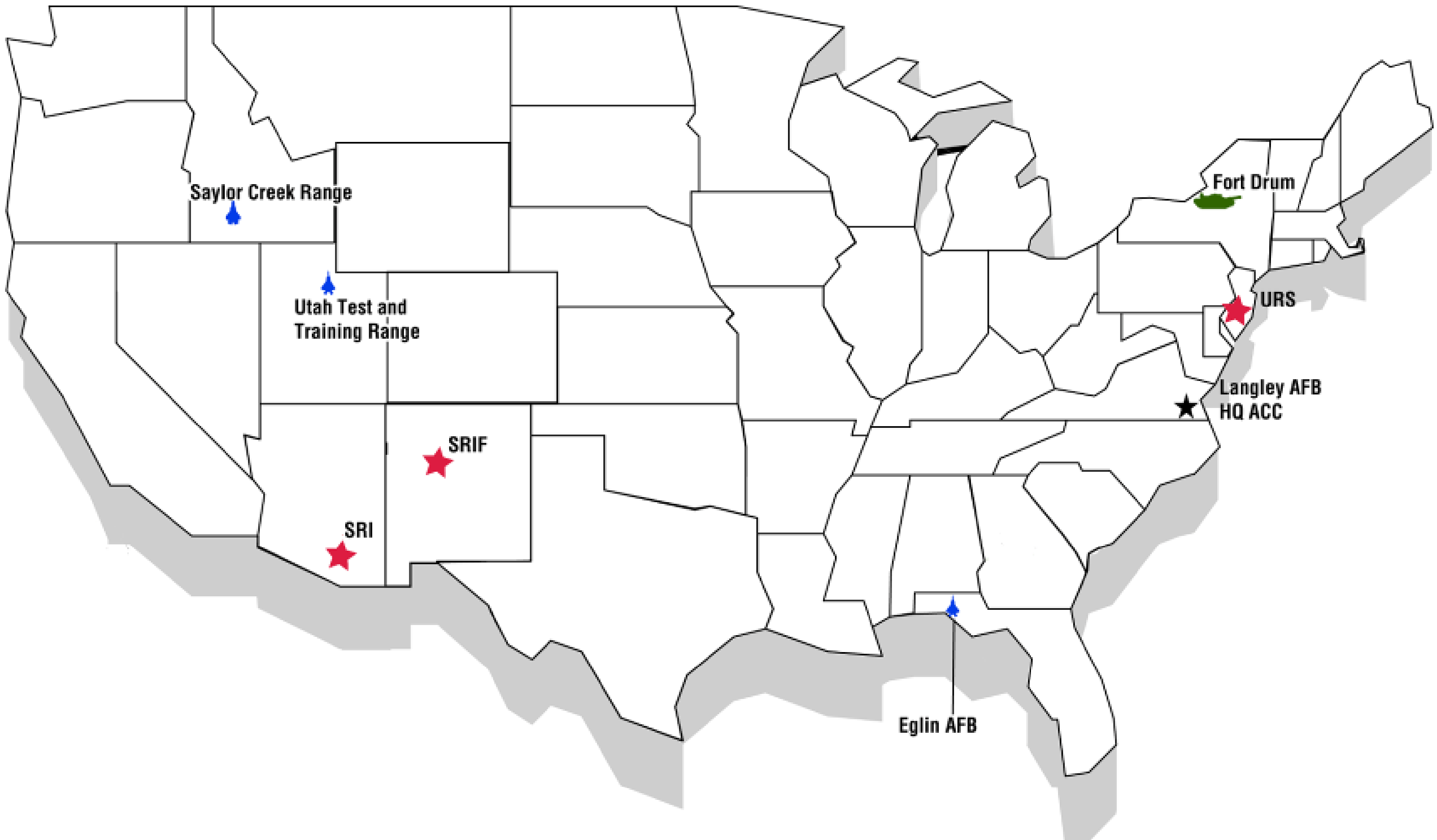


**Figure 2. Location of four demonstration installations, DoD lead agency (U.S. Air Force), and contractors participating in this study.**
Key: HQ ACC; URS Corporation, Inc. (URS); SRIF; SRI.


**Figure 3. General location of Eglin AFB in the panhandle of Florida.**

During the same time period, small platform mounds used for burials of high-ranking individuals and ceremonial functions near Eglin indicate that the Florida Panhandle was incorporated into a large socio-political interaction sphere that affected much of the eastern and south-central United States.

Spanish exploration of the U.S. Southeast starting in the mid-1500s marks the beginning of the early historical period for Eglin AFB (Green et al., 2001). At the time of contact with Europeans in the 1600s, the Late Mississippian-period populations near Eglin were living around Choctawhatchee and East Bays. Spanish, French, British, and American records document aspects of the people and environment of northwest Florida from the later 1600s through the early 1800s. With American control of this region after 1821, evidence of early Euroamerican settlement is present on and near the AFB. Pioneer-period (1821–1865) settlers undertook agriculture (vegetables, cotton, and sugarcane), lumbering, and cattle ranching up to the time of the American Civil War. After the war and the construction of railroads in the early 1880s (Rural Industrial Expansion period, 1865–1930), local populations actively exploited forests for timber and turpentine; significant evidence of their homestead, mills, camps, commercial enterprises, bridges, shipwrecks, roads, and cemeteries is present on the base. These activities dominated the local economy until the 1930s when various programs of the U.S. military established bombing and gunnery ranges on a portion of the Choctawhatchee National Forest (Military Proprietorship period, 1930-present). By the 1940s, Eglin was a military base set aside to test and develop new weapons and munitions, train pilots, and test aircraft. It has continually served these functions since the World War II era. Today Eglin AFB is an important DoD installation whose activities have significantly altered the physical landscape and land-use practices on and near the base and its auxiliary facilities.

## 4.2 SITE LOCATION AND HISTORY: FORT DRUM

Fort Drum is under the jurisdiction of the U.S. Army Installation Management Command (IMCOM), Northeast Region, and is located in upstate New York. It is the home of the 10th Mountain Division, whose mission is to man, train, and deploy rapidly by air, sea, and land anywhere in the world, and be prepared to fight upon arrival and win. Fort Drum consists of 107,265 acres of upland and lowland terrain. Its mission includes command of active component units assigned to the installation, administrative and logistical support to tenant units, support to active and reserve units from all services in training at Fort Drum, and planning and support for the mobilization and training of almost 80,000 troops annually.

### 4.2.1 Site Location and Characteristics

Fort Drum is located in northwestern New York, east of Lake Ontario, north of the Tug Hill Plateau and in the western foothills of the Adirondack Mountain region (Figure 4). The military reservation encompasses portions of Jefferson and Lewis Counties and is entirely in the Ontario-Saint Lawrence drainage basin. Glacial push, melt-water deposition, and isostatic uplift are the primary factors that shaped the fort's current landscape during the final phase of the last ice age.


**Figure 4. General location of Fort Drum in upstate New York, east of Lake Ontario.**

### 4.2.2 Culture History

Human history at Fort Drum also begins during the Paleoindian period and likely dates before the usually accepted beginning date of about 8800 B.C. for the U.S. Northeast. Fluted and unfluted project points associated with a relict shoreline of Glacial Lake Iroquois may be evidence of very early occupation. A maritime adaption in later Paleoindian time is suggested by 8000-year-old hearths along a paleoriver channel that once line the Saint Lawrence and Black River Valleys. The recovery of Paleoindian-style artifacts associated with canoe-building on what would have been an island in Glacial Lake Iroquois during the late Pleistocene and early Holocene epochs suggests that maritime traditions have long been established in the Upper Great

Lakes region. Archaic-period (circa 6300–1500 B.C.) and early to middle Woodland-period (1500 B.C.–A.D. 600) hunter-gatherers and fishers traversed the upland and lowland landforms of Fort Drum and its environs, as evidenced by a series of time-diagnostic projectile point artifacts, and had access to extensive trade networks. By late Woodland times (A.D. 600–1000) access to and creation of ceramic containers, the introduction of maize agriculture, the practice of pipe smoking, the existence of more substantial sedentary villages with storage facilities, and the development of distinctive social classes have expression on Fort Drum. During the Saint Lawrence Iroquois period (A.D. 1300–1550), one of several Iroquoian groups inhabited Fort Drum. Remnants of at least one fortified village of longhouses have been recorded, and research suggests there may be a second village.

The first historically recorded encounters in the Fort Drum region between Native American societies and European explorers, missionaries, and settlers are grouped under the context of the Contact period (A.D. 1540–1768). Although no single component Contact-period site has been recorded on Fort Drum to date, several multi-component sites have been noted. Evidence includes historical-period artifacts and hemlock structural remains dating to the 1650s and trade beads dating to the 1700s. The final, pre-1940, military-era period defined for Fort Drum is the Euro-American Settlement period (A.D. 792–1940), which focuses on the history associated with James LeRay de Chaumont, the Castorland Land Company (land sales), and the construction of the LeRay Mansion—a historically significant property listed in the NRHP (1974).

## 4.3 CULTURAL RESOURCE MANAGEMENT PROGRAM HISTORIES

Both installations have well established CRM programs and large numbers of recorded archaeological sites. The U.S. Air Force has spent over $12.8 million on the CRM program at Eglin AFB since 1998 to conduct Section 106 consultation, archaeological inventory, archaeological site evaluations, and site monitoring and protection. The U.S. Army has spent over $5.5 million on the CRM program at Fort Drum since 1998 to complete Section 106 consultation, archaeological inventory, archaeological site evaluations, and site monitoring and protection on an annual basis. Fort Drum also monitors or protects over 30 archaeological sites per year. Some contractual support is utilized for Section 106-compliance efforts.

Both installations are actively pursuing completion of the inventory and site evaluations, inventorying many thousands of acres and evaluating dozens of archaeological sites per year. Whereas contractors conduct the majority of Eglin's Section 106 consultation efforts, in-house staff conducts most of Fort Drum's Section 106-related activities.

Both installations had previously developed predictive models of archaeological site location. The predictive models for Eglin AFB and Fort Drum were initially evaluated as part of Legacy project #01-167 (Altschul et al., 2004) and the issues identified during that evaluation were addressed as part of model validation. Summary data collected from the CRM programs at Eglin AFB and Fort Drum are presented in Tables 2, 3, 4, and 5.

**Table 2. Eglin AFB CRM program statistics, 1994–2008.**

| Year | Total Survey Acres | New Survey Acres | Old Survey Acres | Survey $K | Total Sites | New Sites | Old Sites | Sites Evaluated | Site Evaluation $K |
|---|---|---|---|---|---|---|---|---|---|
| 1994 | 2945 | 2759 | 186 | — | 20 | 14 | 6 | — | — |
| 1995 | 9386 | 9059 | 327 | — | 143 | 130 | 13 | — | — |
| 1996 | 18,870 | 18,472 | 398 | — | 289 | 276 | 13 | — | — |
| 1997 | 20,150 | 19,352 | 798 | — | 153 | 144 | 9 | — | — |
| 1998 | 11,341 | 10,091 | 1250 | — | 110 | 103 | 7 | — | — |
| 1999 | 10,297 | 9094 | 1203 | $770.00 | 78 | 76 | 2 | 63 | $297.50 |
| 2000 | 11,575 | 11,087 | 488 | $720.00 | 78 | 72 | 6 | 41 | $300.00 |
| 2001 | 20,894 | 19,896 | 998 | $720.00 | 249 | 238 | 11 | 13 | $150.00 |
| 2002 | 10,113 | 10,000 | 113 | $720.00 | 115 | 110 | 5 | 20 | $200.00 |
| 2003 | 6688 | 5983 | 705 | $788.00 | 80 | 62 | 18 | 19 | $200.00 |
| 2004 | 7223 | 6464 | 759 | $844.00 | 56 | 46 | 10 | 21 | $200.00 |
| 2005 | 16,664 | 12,841 | 3823 | $897.00 | 109 | 98 | 11 | 1 | $215.00 |
| 2006 | 14,387 | 12,694 | 1693 | $887.00 | 114 | 99 | 15 | 16 | $215.00 |
| 2007 | 18,092 | 15,280 | 2812 | $880.00 | 146 | 113 | 33 | 12 | $212.00 |
| 2008 | 15,356 | 9408 | 5948 | — | 205 | 144 | 61 | — | — |
| **Total** | **193,981** | **172,480** | **21,501** | **$7226.00** | **1945** | **1725** | **220** | **206** | **$1989.50** |

**Table 3. Fort Drum CRM program statistics, 1994–2008.**

| Year | Total# Crew* | Crew Hrs** | Survey $K | Surveyed Acres*** | Total # of New Sites Found | New Prehistoric Sites | New Historic Sites | Total STPs | Phase 2 Projs | Phase 2 Sites Tested | Phase 2 Costs $K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 6 | 5760 | — | 2693 | 18 | 16 | 2 | 3521 | 2 | — | — |
| 1995 | 25 | 24,000 | — | 3396 | 39 | 29 | 10 | 14,642 | 13 | — | — |
| 1996 | 25 | 24,000 | — | 5938 | 32 | 22 | 10 | 18,252 | 0 | — | — |
| 1997 | 16 | 15,360 | — | 5079 | 26 | 15 | 11 | 19,181 | 2 | — | — |
| 1998 | 20 | 19,200 | $284.50 | 4578 | 40 | 20 | 20 | 17,544 | 8 | 50 | $125.00 |
| 1999 | 26 | 24,960 | $145.00 | 2442 | 34 | 20 | 14 | 14,909 | 15 | 77 | $192.50 |
| 2000 | 42 | 40,320 | $242.00 | 7804 | 87 | 6 | 81 | 35,405 | 6 | 91 | $240.00 |
| 2001 | 36 | 34,560 | $589.00 | 1879 | 34 | 11 | 23 | 26,147 | 14 | 30 | $225.00 |
| 2002 | 27 | 25,920 | $427.00 | 981 | 14 | 3 | 11 | 10,278 | 11 | 14 | $175.00 |
| 2003 | 32 | 30,720 | $203.00 | 568 | 26 | 13 | 13 | 6664 | 26 | 26 | $65.00 |
| 2004 | 25 | 24,000 | $270.00 | 804 | 16 | 4 | 12 | 11,030 | 19 | 16 | $40.00 |
| 2005 | 14 | 13,440 | $188.00 | 700 | 8 | 4 | 4 | 8264 | 4 | 8 | $20.00 |
| 2006 | 9 | 8640 | $158.50 | 277 | 17 | 13 | 4 | 3571 | 2 | 17 | $42.50 |
| 2007 | 10 | 9600 | $185.50 | 113 | 22 | 20 | 2 | 2403 | 6 | 21 | $52.50 |
| 2008 | 27 | 25,920 | $259.00 | 735 | 12 | 8 | 4 | 10,329 | 7 | — | — |
| **Totals** | **340** | **326,400** | **$2951.50** | **37,988** | **425** | **204** | **221** | **202,140** | **135** | **350** | **$1177.50** |

Note: STP stands for shovel test pit; these are exploratory excavations undertaken during survey to locate buried artifacts and features. Phase 2 is the phase after initial survey when STPs that yielded artifacts or features are further explored and the results evaluated.
* Not all crew were working on survey.
** Assumes 8 hours/day, 40 hours/week for 6 months.
*** Total acres surveyed during 1998–2008 (20,881 acres) were used to calculate survey cost per acre.

**Table 4. Status of site inventory and site count for Eglin AFB and Fort Drum as of 2008.**

| Installation | Total Acreage | Inventoried Acreage | Disturbed Acreage | Unsurveyed Acreage | Total Sites |
|---|---|---|---|---|---|
| Eglin AFB | 463,128 (100%) | 193,981 (41.9%) | 10,000 (2.1%) | 259,147 (56.0%) | 1945 |
| Fort Drum | 107,625 (100%) | 37,988 (35.3%) | 28,263 (26.2%) | 41,374 (38.4%) | 991 |

Note: Disturbed Acreage is land that cannot be inventoried because of the presence of the cantonment, airstrips, large bodies of water, and so forth.

**Table 5. Metrics using data reported from Eglin AFB and Fort Drum.**

| Installation | Historic Discovery Rate: Sites per Inventoried Acre | Historic Average Cost per Inventory Acre | Historic Average Evaluation Cost per Site/Project |
|---|---|---|---|
| Eglin AFB | 0.010 | $62.33 | $9657.77 |
| Fort Drum | 0.011 | $141.35 | $3364.28 |

Data in Tables 2, 3, and 4 indicate that expenditures for NHPA Section 106 compliance, inventory, and evaluation vary, which suggest that archaeological preservation, resource visibility, field methods, political realities, and management challenges greatly influence the cost and time of CRM endeavors. DoD has yet to develop a strong, objective, and systematic approach for discovering, recording, evaluating, and managing cultural resources on military reservations in the United States. What constitutes adequate inventory at one installation is not the same as another.

Data in Table 5 suggest that the contrasting cultural histories and environmental settings of coastal Florida and upstate New York result in significant different average survey costs. Despite a similar rate of site discovery, differences in the archaeological record, soil conditions, vegetative cover, geomorphic setting, and field methods contribute to the difference in average cost per survey between these two installations.

In this report, the historical average cost per inventory acre (a.k.a. the per-acre survey cost) was used as one of several metrics to evaluate the effectiveness of predictive modeling to streamline Section 106 and NEPA compliance.

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# 5.0 TEST DESIGN

This project demonstrates that (1) predictive models developed for DoD installations can predict with acceptable accuracy the locations of archaeological materials, and (2) the modeling process can be successfully integrated into programmatic approaches to cultural resource compliance. To accomplish the first component of the demonstration, the predictive models were systematized, refined, and validated for two demonstration installations—Eglin AFB and Fort Drum. For the second component of the demonstration, work was conducted with Eglin's and Fort Drum's CRM staff and stakeholders to integrate the models into the installation's cultural resource compliance programs. The latter will be accomplished through the use of Section 106 PAs (see Appendices B and C for draft PAs for Eglin and Fort Drum).

## 5.1 CONCEPTUAL TEST DESIGN

Our approach recognizes that modeling is a process. As new data are incorporated, models become better predictors of site location. It follows that models need to be repeatedly tested, refined, and validated using appropriate statistical techniques and the latest, quality-controlled data. Still, the most sophisticated and accurate model will not be useful if it has not gained user-acceptance or not been integrated into an installation's cultural resource compliance efforts. Predictive models will only be successful components of programmatic approaches to cultural resource compliance once a minimal level of accuracy and reliability is achieved and accepted by concerned stakeholders.

The modeling process for the project is presented in Figure 5. Predictive models are divided into surface and subsurface models. The surface models were further divided between those that model all prehistoric sites (regardless of site type) from those that model only a subset of prehistoric sites—intensively used residential sites—these sites were identified as cultural resource compliance red flags. Surface and subsurface (deeply buried sites) predictive models are commonly presented as sensitivity maps in which the study area is divided into areas of low, medium, or high archaeological sensitivity. Most predictive models developed for DoD installations are surface models of all sites based on the results of traditional surface survey. Less often, installations have constructed subsurface models based on geomorphic variables; rarely are red flag models developed. Combining subsurface and surface models into integrated, zonal management models will be essential for accurately predicting the relative importance of site types and the three-dimensional distribution of archaeological resources, assuring stakeholder buy-in and streamlining compliance.

Our general procedures for each demonstration installation involved a variety of steps (see the five phases depicted in Figure 5). The first step is to gather all existing modeling and inventory data for each installation. This is followed by evaluation of data quality, reconstruction of the original models in a GIS, and preliminary assessment of the models using validation techniques and exploratory data analysis. Once the models were assessed, the project team worked with installation personnel to develop a plan for systematizing the baseline models, refining the baseline models, and validating the refined models. An acceptable model was a model that met or exceeded the performance objectives described in Section 3.0 and discussed more fully in Section 6.0. Following the development of surface and subsurface models that met our performance standards, the project team combined the separate models into a single model using

various transformational procedures. This integrated model is referred to as the zonal management model; it displays zones of contrasting sensitivity for the presence of archaeological sites and is used as the basis for consultation with stakeholders regarding levels of effort and protection afforded to sites in each zone for a given period of time. The negotiated and agreed-upon procedures will be incorporated within a signed and executed PA document that will streamline NHPA Section 106 compliance.

## 5.2 BASELINE CHARACTERIZATION AND PREPARATION

The baselines for this project are threefold: (1) existing predictive models prior to systematization, (2) the baseline performance of existing but systematized predictive models prior to statistical validation and refinement, and (3) CRM program performance (i.e., NHPA Section 106 and NEPA compliance measures) prior to model integration.

## 5.3 DESIGN AND LAYOUT OF TECHNOLOGY AND METHODOLOGY COMPONENTS

Predictive modeling technology implemented in this demonstration consists of surface models (all-sites models and red flag models), subsurface models, and zonal management models. The development of successful models allowed us to prepare draft PAs, which when finalized, will facilitate the management of archaeological sites on each installation, improve communication between installation CRM and its stakeholders, and streamline compliance with federal regulations.

## 5.4 FIELD TESTING

Testing of the predictive models for Eglin and Fort Drum began in February 2009 and extended through August 2010. For each installation, the baseline surface model was systematized, refined, and validated and a preliminary subsurface model was constructed using available geological and archaeological information. A red flag model was created for Eglin AFB. A zonal management model integrating surface (including the red flag model, if developed) and subsurface models installation was also created. Outlined below are the field testing requirements for each installation and model.

### 5.4.1 Eglin AFB

- Acquire existing archaeological predictive models.
    - Partially systematized all-site surface model for prehistoric sites (Thomas and Campbell, 1993; Prentice Thomas Associates, 2005) expressed as either high-sensitivity or low-sensitivity zones.
        - High sensitivity areas are locations less than 200 meters (m) from potable water and less than 15.24 m above potable water; all other areas are low sensitivity.
- No subsurface model.
- No red flag model.

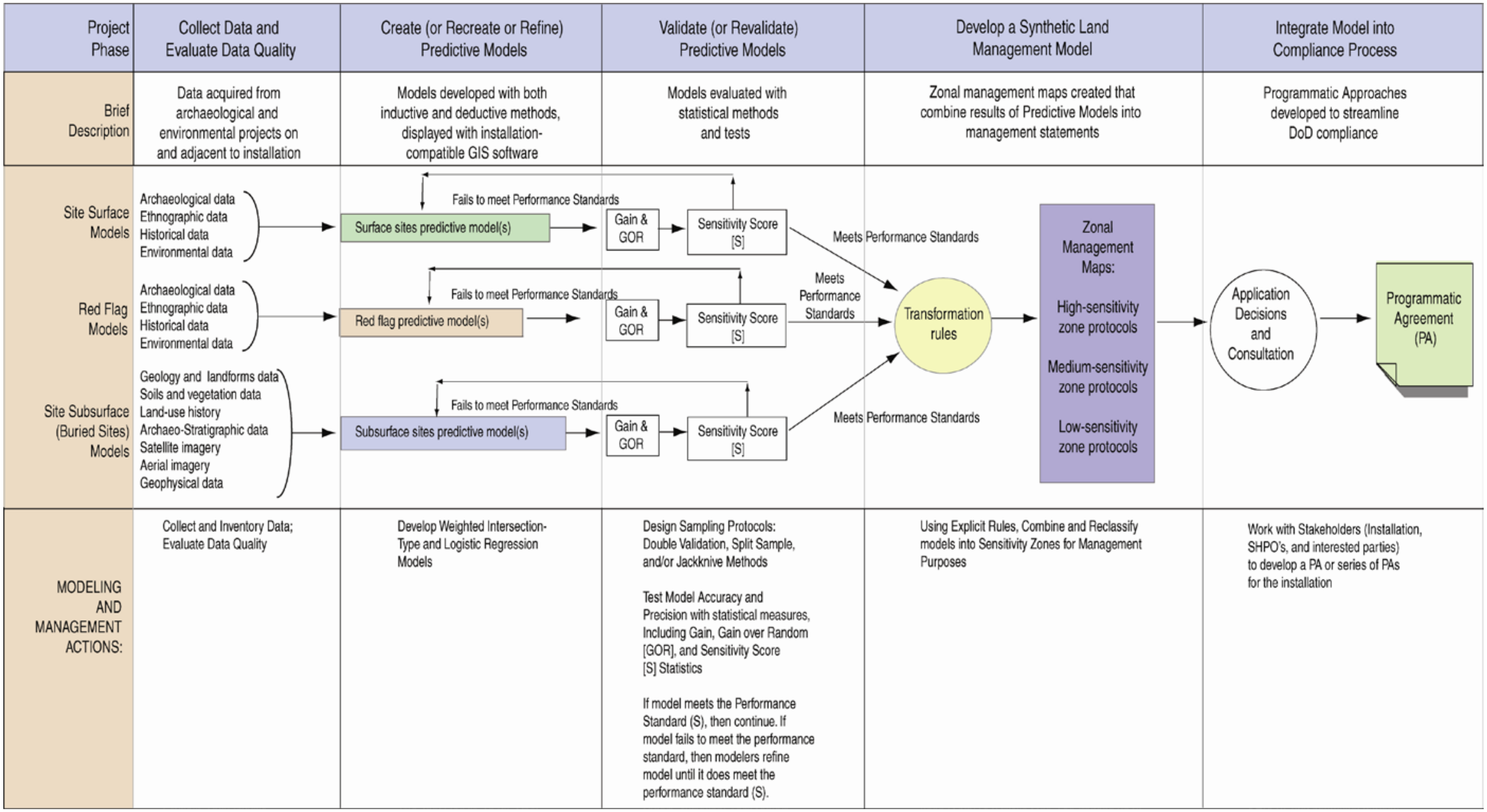


**Figure 5. Annotated flow diagram illustrating the demonstration technology process.**
Note: Alterative modeling techniques (Random Forest and Artificial Neural Networks) also were used.

- Recreate and operationalize existing surface model in a GIS; this becomes the "baseline" model evaluated in all comparative analyses (Figure 6).
    - Location of freshwater stream networks, springs, seeps, and ponds recorded in U.S. Geological Survey (USGS) National Hydrography Dataset expressed as polygons, points, and lines in a GIS were used to calculate the Euclidean distance to and above potable water in a raster cell data layer assigned elevation values derived from the National Elevation Dataset.
        - High Sensitivity (29%): Areas close to potable water (drainages, springs, seeps).
        - Low Sensitivity (71%): Areas further away from potable water sources.

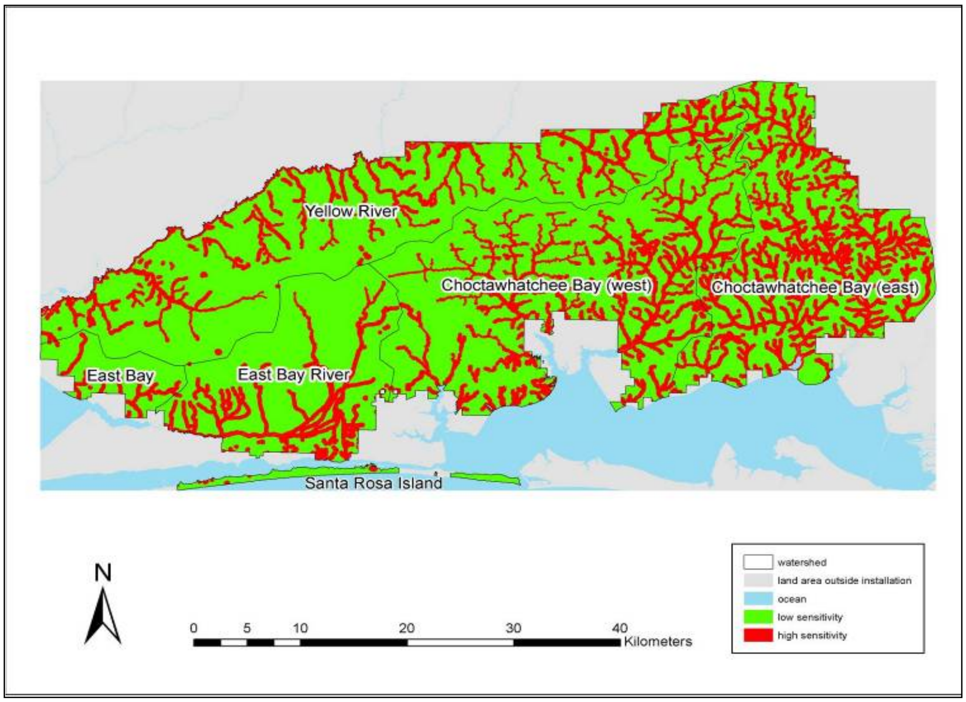


**Figure 6. The Eglin AFB baseline surface model, operationalized in a GIS.**

- Validate baseline model with statistical measures (e.g., double-validation sampling techniques, overall performance with Gain, and GOR).
    - Testing of the model using available CRM data and validation statistics revealed the model works quite well for many areas of the installation as well as for common prehistoric site types.
- Refine baseline model with additional data and one or more modeling techniques. (Figures 7 and 8).
    - Installation divided into a series of watersheds using data from National Hydrography Dataset; site type and temporal affiliations developed for individual sites using information in Eglin AFB CRM database. Exploratory data analyses undertaken to ascertain whether or not other environmental variables correlated

with site location. Based on these studies, new variables were added; certain site types were associated with specific ecological zones, wetland edges, edges of soils with thick “A” horizons, hydrological network junctions, areas of high vegetation diversity, and coastal settings. Random Forest modeling (Breiman, 2001; Freeman and Frescino, 2009) used to predict that a site would be present or absent in a given area, first by individual watershed and later combined into a single, installation-wide surface model.

- High Sensitivity (17%): Areas close to potable water (drainages, springs, seeps), in proximity to specific ecological zones, wetland edges, edges of soils with thick “A” horizons suspected to be former wetlands, near hydrological network junctions, areas of high vegetative diversity, or near coasts.
- Low Sensitivity (83%): Areas further away from water sources.

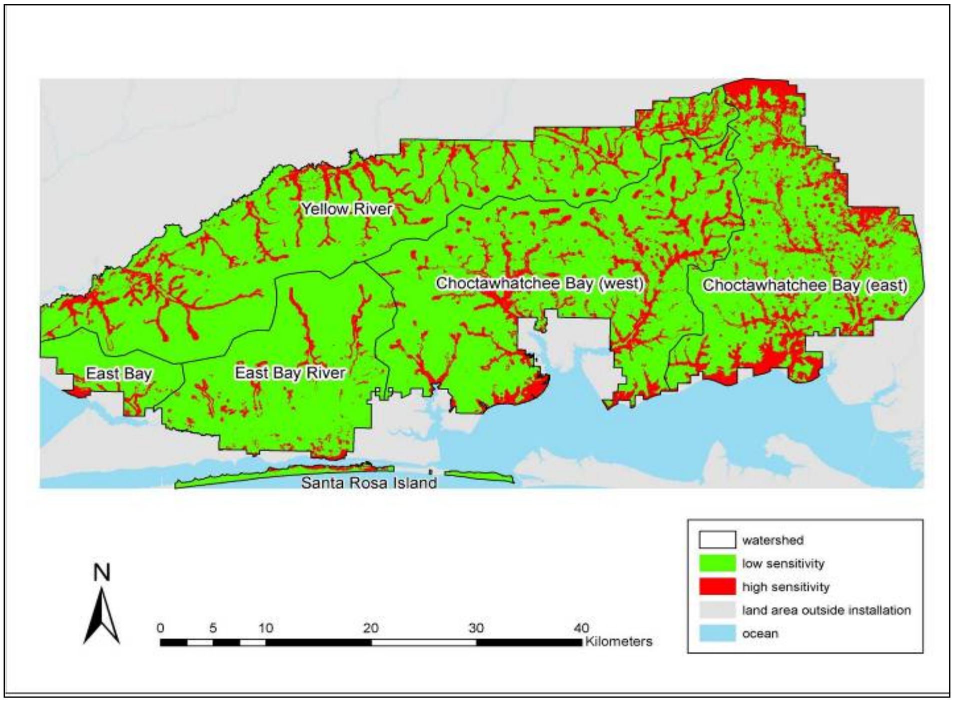


**Figure 7. The Eglin AFB refined surface model.**

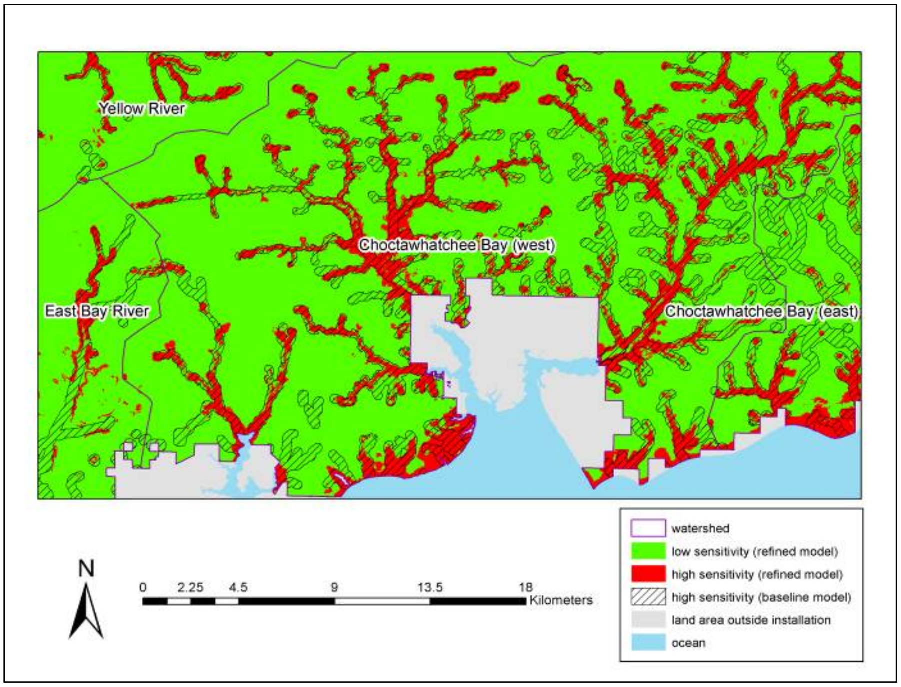


**Figure 8. A close-up view of the Eglin AFB refined surface model in the western half of the Choctawhatchee Bay watershed.**

- Validate refined prehistoric sites surface model with statistical measures.
  - Refined model improve results and met performance standards (Table 1).
- Create a preliminary subsurface model with existing geomorphology and soils data (Figure 9).
  - Results indicated there is a strong potential for buried archaeological sites in a number of settings, but most of Eglin AFB has low to no probability for buried deposits. However, there is insufficient independent CRM data to test this preliminary model (Table 1).
    - High Sensitivity (7%): Areas that include late Pleistocene and Holocene alluvial valley fill in major drainages, lower reaches of creeks draining into Choctawhatchee Bay, low lying coastal areas especially around protect bays where surface buried by tidal surge deposits, and areas between or below stable dunes on Santa Rosa Island.
    - Medium Sensitivity (11%): Areas that include colluvial footslopes within dissected valleys of Western Highlands and East Bay Swamp.
    - Low Sensitivity (82%): The majority of the interior installation and areas dominated by undissected Pleistocene and earlier coastal plains of the Western Highlands.

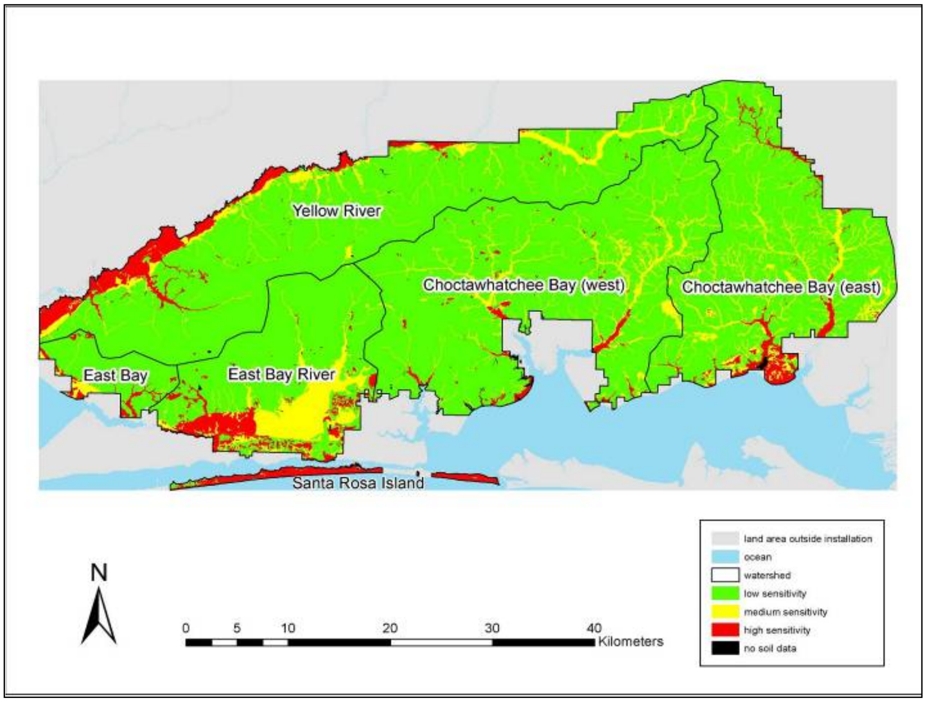


**Figure 9. The Eglin AFB subsurface model.**

- Create red flag model for specific site type(s) (Figure 10).
    - Using Eglin's CRM database, the following site types were identified: campsite, collection station, burial site, mound site, village/hamlet, and site of undetermined function. Sites classified as village/hamlets, burial sites, and mound sites were used to represent sites that would be costly to mitigate should they be discovered or impacted during installation activities. Therefore, these three types were considered "red flags." The same approach to constructing the refined model was used, but the entire installation, rather than individual watersheds, were used as spatial universe. The resulting model predicts these red flag sites to be located along the coast near estuaries and inlets, on Santa Rosa Island, in the vicinity of large wetlands along the Yellow river, and East Bay River, and in the interior of the installation near river headwaters and springs. Red flag sites are located in locations representing less than 3% of the entire installation.

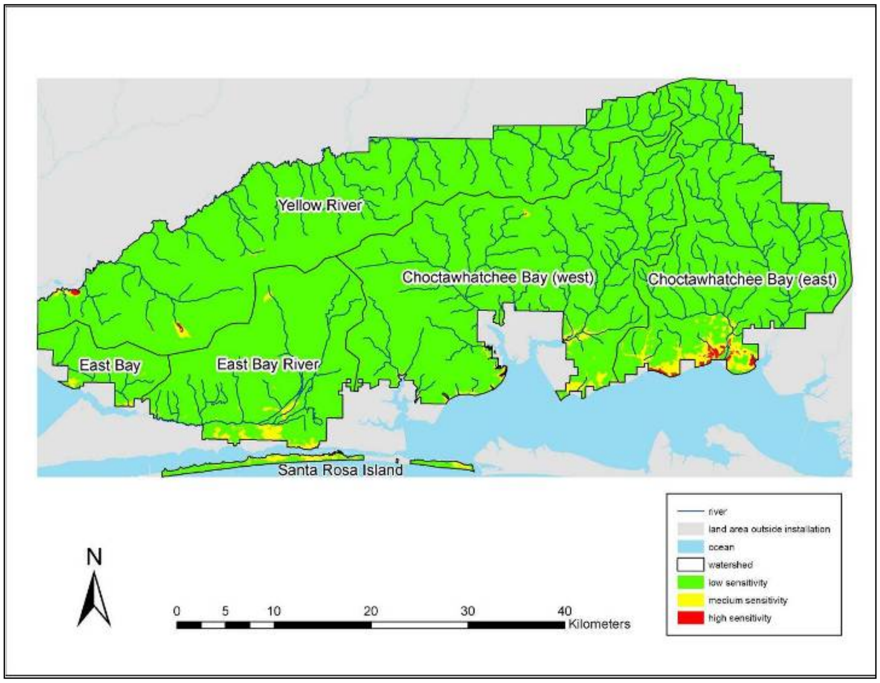


**Figure 10. The Eglin AFB red flag model.**

- Validate red flag model with statistical measures.
  - Red flag model was very successful and well exceeded the performance criteria for success (Table 1).
- Create zonal management model and validate with statistical measures (Figure 11).
  - Zonal model created by intersecting the validated, refined, all-sites surface model; validated red flag model; and preliminary subsurface model in a GIS using transformation rules that derive a map that integrates the results of the underlying models. This final model expressed as a map displays locations on the installation where surface and subsurface sites are predicted to be few in number and potentially less informative (low-sensitivity zones), greatest in number and potentially information rich (high-sensitivity zones), or something intermediate (medium-sensitivity zones).
    - High Sensitivity (18%): Any area that was either high sensitivity in refined surface model or either high or medium sensitivity in red flag model.
    - Medium Sensitivity (11%): Any area that were low sensitivity in the surface model, low sensitivity in the red flag model, and either high or medium sensitivity in the subsurface model.
    - Low Sensitivity (71%): Any area not classified as either high or medium sensitivity.

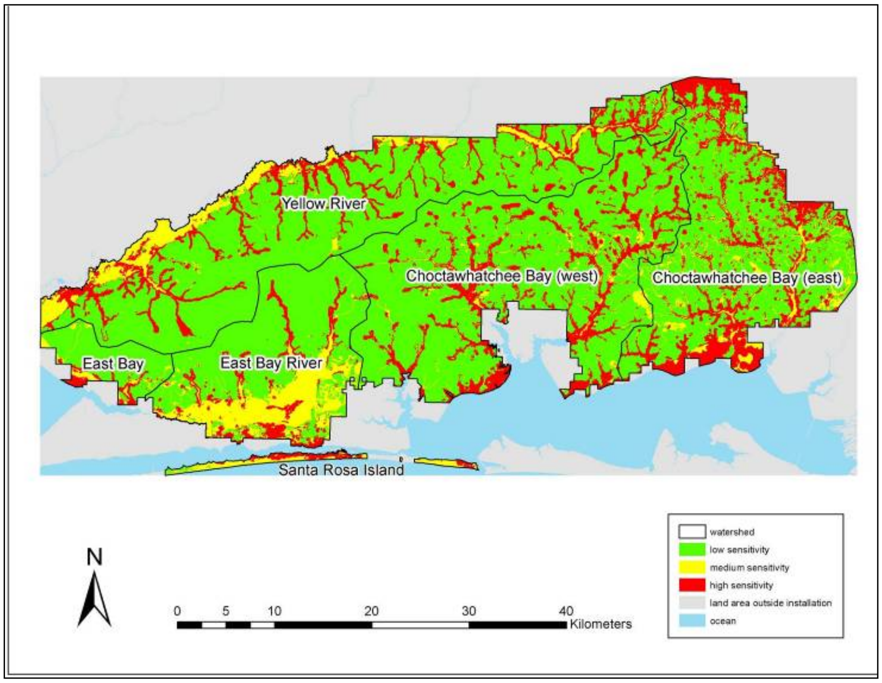


**Figure 11. The Eglin AFB zonal management model.**

### 5.4.2 Fort Drum

- Acquire existing archaeological predictive models.
  - Two partially systematized surface models: Glacial Lake model (Rush et al., 2003; Rush et al., 2006) and Upland model (Wood, 2005).
    - The Glacial Lake model was developed to identify lowland areas (i.e., the Lake Plains, Pine Plains, and Alluvial Floodplain zones) where Paleoindian, Archaic, and Early Woodland sites could be located with respect to features of a Pleistocene-age lake and its tributaries. Predictor variables included elevation, distribution of glacial landforms, and proximity to ravines and relict waters. The temporally stable shoreline of Glacial Lake Frontenac (circa 11,200 B.C.) estimated at the 600 feet (ft) (183 m above mean sea level [AMSL]) contour around which Paleoindian sites found. A series of earlier but less stable shorelines Glacial Lake Iroquois identified up to 780 ft (238 m), with sites concentrated at 700–740 ft (213–226 m AMSL), but also found along the 680 ft (207 m) contour.
    - The Upland Model was developed to identify upland areas (i.e., foothills of the Adirondack Mountains) where sites would be located. Predictor variables included terraces, portage locations, and areas located within 10 m of a waterway.
  - No subsurface model.
  - No red flag model.

- Recreate and operationalize the two existing surface models in a GIS; these become the "baseline" models evaluated in all comparative analyses (Figures 12 and 13).
    - Variables used in the construction of both surface models used, refined, and augmented data drawn from the National Hydrography Dataset Plus, Geospatial Wetlands Digital Database, National Elevation Dataset, and National Land Cover Database were used. Sensitivity predicted per physiographic zone.
        - For the Glacial Lake Model, the following landscape features were identified: fossil islands, ravines, lake shores, and relict water bodies.
            - High Sensitivity (13%): Areas with fossil islands, ravines, lake shorelines, relict waters.
            - Medium Sensitivity (44%): Areas of Pine Plains not classified as high sensitivity; 100 m of streams in Lake Plains and Alluvial Floodplains.
            - Low Sensitivity (44%): Remaining areas not defined as high or medium sensitivity above.

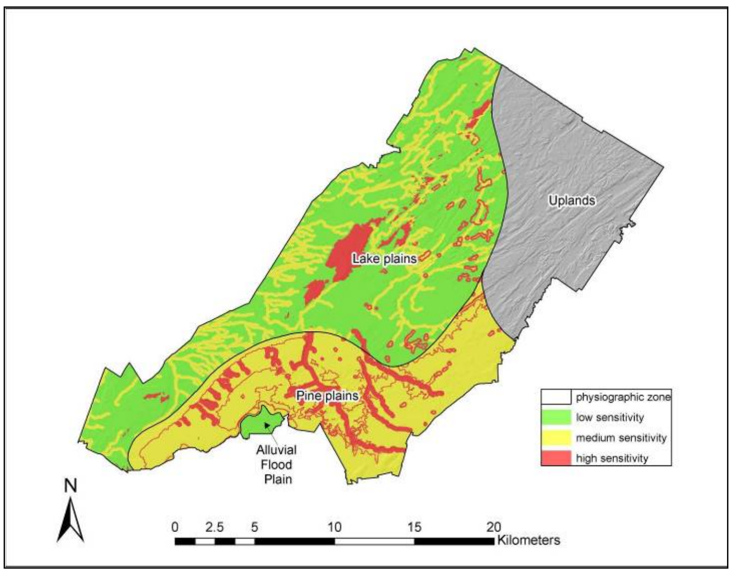


**Figure 12. The baseline Glacial Lake surface model for Fort Drum.**

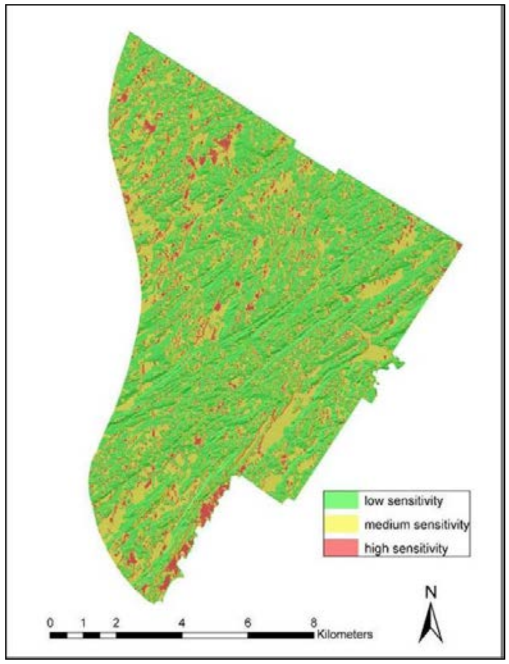


**Figure 13. The baseline Upland surface model for Fort Drum.**

  - For the Upland Model, river and lake terraces, portage locations, and areas within 10 m of a waterway were identified.
    - High Sensitivity (7%): Areas that contained two or more of the following: terrace area, potential portage area, and were within 10 m of a waterway.
    - Medium Sensitivity (39%): Areas that contained only one of the above.
    - Low Sensitivity (54%): Remaining areas without any of the above.

- Validate baseline model with statistical measures (e.g., double-validation sampling techniques, overall performance with Sensitivity Score, Gain, GOR).
  - Testing revealed that the Glacial Lake Model performed reasonably well, although it did not meet our performance measure. The Upland Model performed poorly.
- Refine baseline models with additional data and a one or more modeling techniques to create a single, installation-wide surface model (Figure 14).
  - K-means cluster analysis used to develop site classes according to their environment associations (three for upland zones and five for lowland zones), which served as a training data set. Artificial Neural Network (ANN) modeling (Huang and Lecturn, 2006; Gershenson, n.d.; LeCun et al., 1998; LeCun and Bengio, 2002; Rust, 2010) used to classify the probability that every GIS raster cell would or would not contain sites. The process performed for both the Glacial Lake (lowland zones) and Upland (upland zones) models. The resulting models merged to create a single, installation-wide surface model.
    - High Sensitivity (12%): Areas classified as high sensitivity in both models.

- Medium Sensitivity (14%): Areas classified as medium sensitivity in both models.
- Low Sensitivity (74%): Areas classified as low sensitivity in both models.

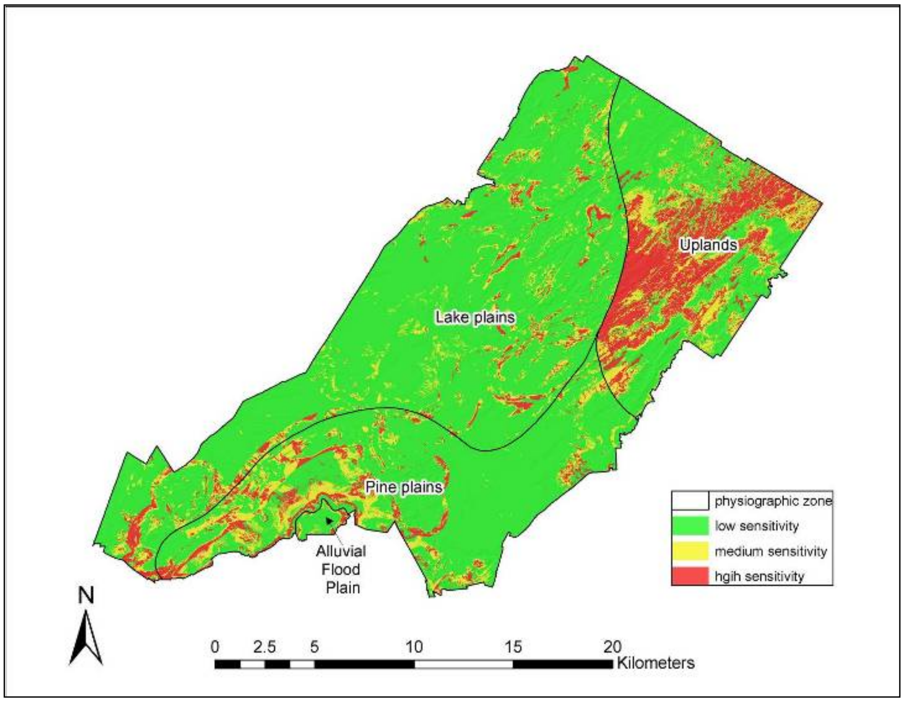


**Figure 14. The refined surface model for Fort Drum.**

- Validate refined prehistoric sites surface model with statistical measures.
  - Refined model improve results and met performance standards (Table 1).
- Create a preliminary subsurface model with existing geomorphology and soils data (Figure 15).
  - Data sources for modeling buried site probability include geological literature, state geological maps, and NRCS soil maps for Fort Drum. Geology and soil layers used to define areas according to their probability for containing buried archaeological deposits at least 1 m deep. Additionally, shoreline elevations were modified to account for isostatic rebound subsequent to the melting of glacial ice.
    - High Sensitivity (10%): Areas with glaciolacustrine beach deposits and Holocene and late Pleistocene alluvium.
    - Medium Sensitivity (29%): Areas of aeolian deposits and organic-rich deposits such as swamp deposits, and glaciofluvial stream deposits.
    - Low Sensitivity (61%): Areas not classified as high or medium sensitivity including areas of moraine deposition, till deposits, and bedrock.

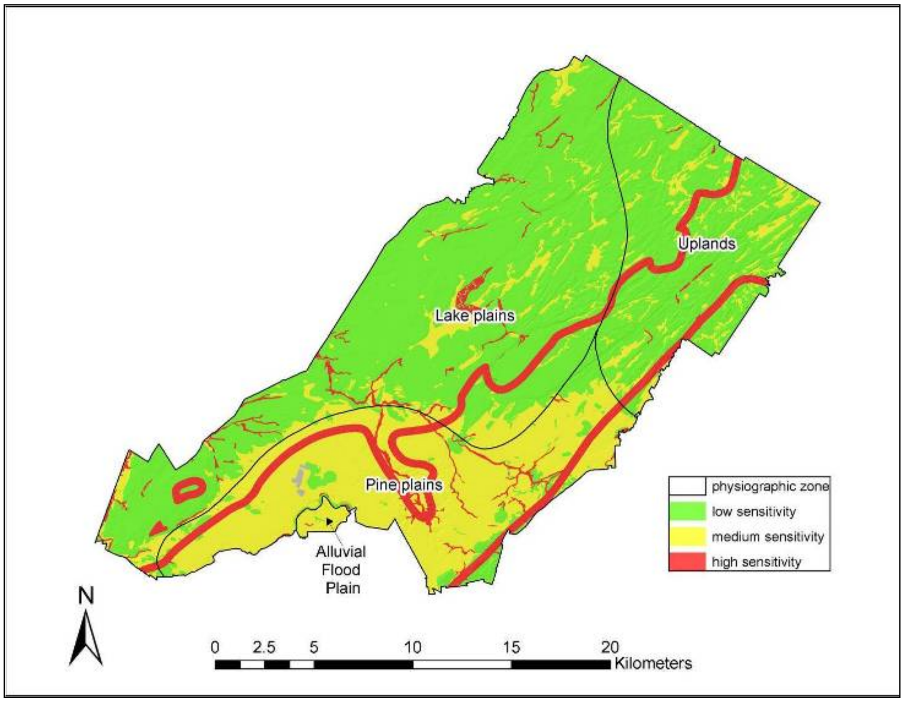


**Figure 15. The preliminary subsurface model for Fort Drum.**

- Create zonal management model and validate with statistical measures (Figure 16).
  - Zonal model created by intersecting the validated, refined, all-sites surface model and the preliminary subsurface model in a GIS using transformation rules that derive a map that integrates the results of the underlying models.

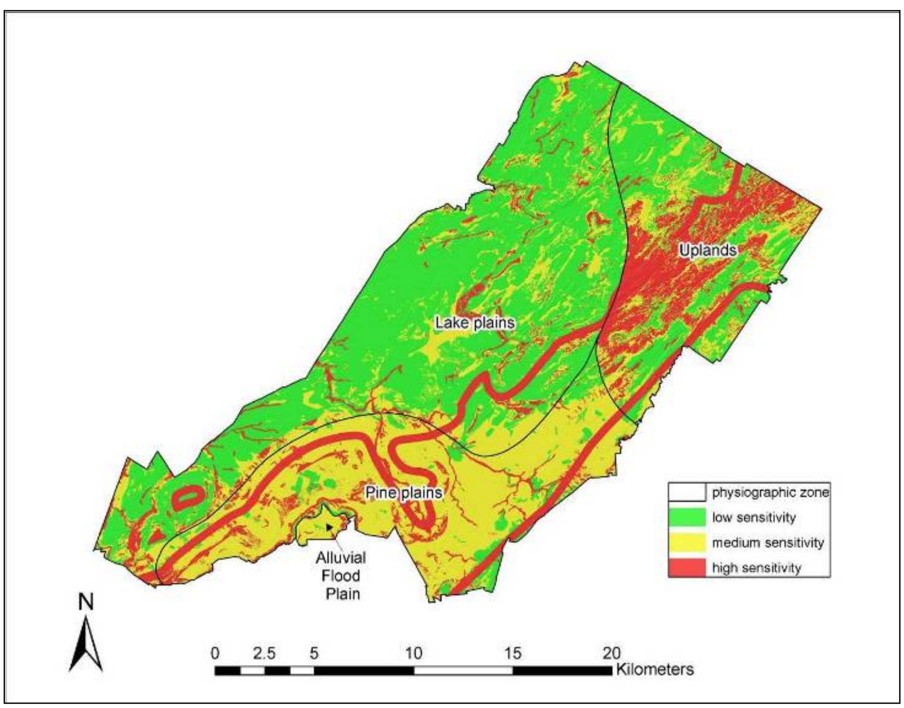


**Figure 16. The zonal management model for Fort Drum.**

## 5.5 SAMPLING PROTOCOL

### 5.5.1 Validation of Surface Site Models

The response variable in site location modeling is binary, consisting of site and non-site locations, therefore, samples used in model building and testing had to be drawn from within recorded site areas as well as from areas that have been surveyed, but where no site has been recorded. Random point samples were generated in ArcGIS from within site areas to develop site samples. To develop non-site samples, random point samples were generated from previously surveyed areas where no site had been discovered. In the case of Eglin, sample strata consisted of individual watersheds and site types. In the case of Fort Drum, sample strata consisted of physiographic regions and arbitrary site classes defined through K-means cluster analysis.

At Eglin AFB, site samples could be drawn from polygons representing prehistoric site boundaries, as sites are conventionally defined as bounded polygons in the Eglin AFB CRM program. Non-site samples were drawn from surveyed areas and were restricted from being within 150 m of a site boundary.

At Fort Drum, site boundaries rarely have been established and polygons representing site boundaries were uncommon. Many prehistoric sites at Fort Drum are represented by a point representing the approximate location of the site, rather than being represented by a polygon. To establish site samples for modeling at Fort Drum, prehistoric site locations were identified using the CRM database. Existing polygon boundaries were used for a few sites that had explicitly defined boundaries whereas boundaries for the remaining sites were derived in a GIS. To establish the site boundary for a site defined only as a point, positive STPs (identified using the STP database) located within 50 m of a prehistoric site point also were considered to be part of a site. These point data were then used to create a spatial extent boundary of "convex hulls" around the site and served to define the site polygon. These areas were then merged with prehistoric sites for which polygons had been defined. Non-site samples were chosen from within survey areas in locations that were at least 50 m from an area defined as site.

For any given strata, site and non-site samples were randomly reduced in size to develop site and non-site samples that were roughly equivalent in size, in keeping with standard practice. Typically, training sample sets consisted of approximately 10 to 20% of the larger site and non-site sample from which they were drawn. This process usually resulted in approximately 60% of sites in a given strata being sampled for model training. The remaining samples were used as a testing set.

A major component of this demonstration plan is statistical validation of the models. Validation is a family of statistical approaches used to test predictive models. Sampling methods for assessing the validity of predictive models include split-sample, resampling, and "double validation" methods (Rose and Altschul, 1988). The first two validations methods are dependent on using subsamples drawn from the same sampling population. The third is based on testing with independent data. Due to the dependency between the predicted and actual site locations, the first two approaches can generate an overly optimistic assessment of model performance. The third requires validation data that were not drawn from the sampling population used to build the model. Statistical validation measures designed to deal with precisely these kinds of contexts

have been developed and were implemented as a part of this project (Kvamme, 1988, 1990; Rose and Altschul, 1988). For details on how these validation techniques were applied to data at Eglin AFB and Fort Drum see Green et al. (2012).

### 5.5.2 Validation of Subsurface Site Models

An important component of our predictive modeling effort involves delineating where buried archaeological sites may exist within the demonstration installations based on available information. This information was used to create a preliminary subsurface model. Comprehensive validation of subsurface models would entail conducting field research to document the ages of sediment-landform assemblages likely to be associated with buried sites, however, such an effort is clearly beyond the scope of the current study. However, the project team was able to use STP data at Fort Drum to identify buried cultural deposits discovered during a previous survey in order to perform a preliminary test of the subsurface model. Information on buried deposits at Eglin has thus far been anecdotal and incomplete and has not been sufficient to validate the subsurface model for Eglin.

## 5.6 SAMPLING RESULTS

The major factor affecting sampling results is the reliability and representativeness of survey. For any archaeological predictive model, the performance of the model is ultimately constrained by the extent and representativeness of survey and site discovery and recording methods. For instance, both Eglin AFB and Fort Drum use STPs to discover sites during inventory, but apply different methods in doing so. At Fort Drum, STPs are placed systematically at standard intervals throughout a survey area. Standard survey intervals at Fort Drum are generally between 5 and 20 m and are commonly 15 m. At Eglin AFB, STPs are generally placed at a wider interval, 50 m or more, and although spaced relatively evenly apart, are placed in a more judgmental fashion. This is largely because Eglin AFB is an exceptionally wet environment where the practical placement of a STP in a location likely to contain a site has to be adjusted in the field frequently due to ground conditions encountered during fieldwork. The result is that STPs at Eglin cover survey areas less evenly and at a lower density of effort than at Fort Drum.

Due in part to the practical constraints on the placement of test pits at Eglin AFB, STPs excavated at Eglin AFB are larger than those excavated at Fort Drum. STPs at Eglin are 50 x 50 centimeters (cm) in plan view while those at Fort Drum are 30 x 30 cm in plan view. The larger STP size at Eglin helps to elevate site discovery rates, but overall, the wider survey interval translates into the greater probability at Eglin AFB that sites will be missed. In addition, the greater variability in STP placement at Eglin AFB results in greater variability between inventoried areas in survey reliability (Heilen et al., 2008).

At both Eglin AFB and Fort Drum, survey reliability varies spatially and temporally, resulting in samples that are less than ideal, but are generally adequate for modeling purposes.

### 5.6.1 Eglin AFB Sampling Results

The survey that was conducted on Eglin AFB is shown in Figure 17, along with the location of streams and wetlands. Generally speaking, the survey has focused on areas relatively close to

potable water sources in fairly restricted environmental settings (for example wetlands and the Sandhill ecological complex have rarely been surveyed). STP locations are moved or abandoned depending on their feasibility because the precise location of survey using shovel testing methods used to discover archaeological deposits is often adjusted in the field due to ground conditions. As a result, using GIS to determine which areas have actually been shovel tested is not always straightforward.

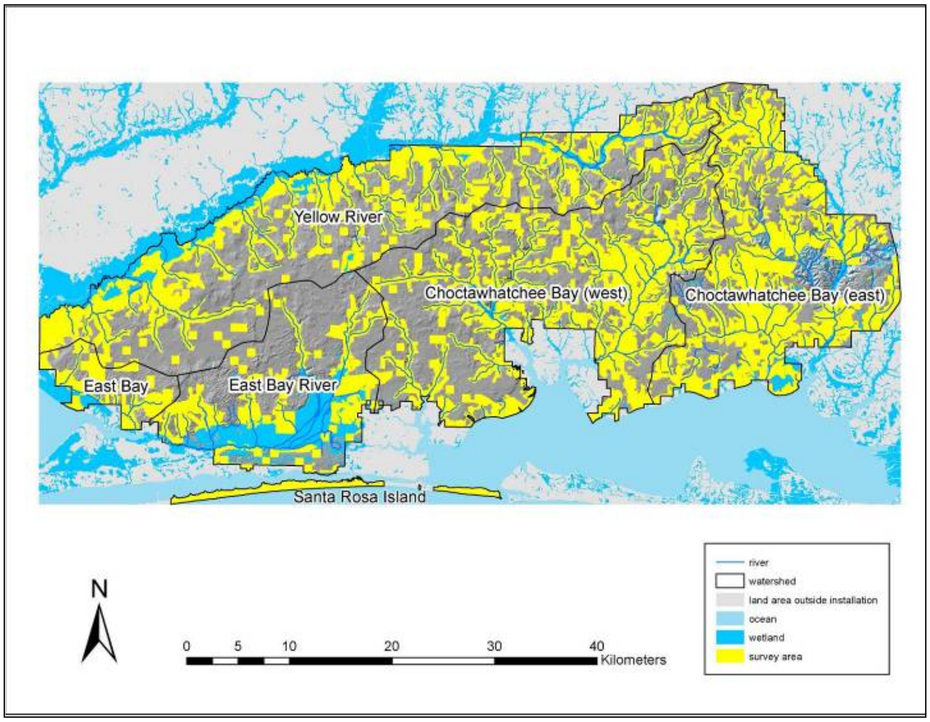


**Figure 17. Eglin AFB survey areas, as of 2008.**

To identify a sample of sites and non-site locations to test the results of the refined surface model, the project team allowed site and non-site samples to be drawn from any location indicated in the GIS data as surveyed land. This includes some areas that have been recorded as survey, but likely have been subjected only to judgmental survey or pedestrian survey with limited subsurface testing.

The distribution of positive and negative sample locations with respect to the predictions of the Eglin refined surface model, which consists of low-sensitivity and high-sensitivity zones, is presented in Table 6. The sample consists of roughly 9500 test locations, half of which are located within sites; the remaining half of the samples consists of surveyed locations where a site has not been discovered. Overall, more than 98% of site-positive samples occurred within the high-sensitivity zone, while the remainder of site-positive samples occurred within the low-sensitivity zone. Eighty percent of site-negative sample locations occurred in the low-sensitivity zone, while 20% of site-negative sample locations occurred in the high-sensitivity zone.

**Table 6. Distribution of positive and negative sample locations at Eglin AFB and correspondence to predictions of the refined surface model.**

| Watershed | Low-Sensitivity Zone | | | | High-Sensitivity Zone | | | | All Sensitivity Zones | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Positive Samples | Negative Samples | % Total Positive Samples | % Total Negative Samples | Positive Samples | Negative Samples | % Total Positive Samples | % Total Negative Samples | Positive Samples | Negative Samples | % Total Positive Samples | % Total Negative Samples |
| Santa Rosa Island | 6 | 185 | 3.0% | 92.0% | 192 | 16 | 97.0% | 8.0% | 198 | 201 | 49.6% | 50.4% |
| Choctawhatchee Bay (east) | 35 | 1,505 | 1.9% | 79.6% | 1847 | 386 | 98.1% | 20.4% | 1882 | 1891 | 49.9% | 50.1% |
| Choctawhatchee Bay (west) | 17 | 920 | 1.5% | 80.3% | 1124 | 226 | 98.5% | 19.7% | 1141 | 1146 | 49.9% | 50.1% |
| East Bay | 3 | 159 | 1.8% | 91.9% | 168 | 14 | 98.2% | 8.1% | 171 | 173 | 49.7% | 50.3% |
| East Bay River | 4 | 326 | 1.1% | 88.8% | 359 | 41 | 98.9% | 11.2% | 363 | 367 | 49.7% | 50.3% |
| Yellow River | 11 | 753 | 1.1% | 76.6% | 968 | 230 | 98.9% | 23.4% | 979 | 983 | 49.9% | 50.1% |
| Total | 76 | 3848 | 1.6% | 80.8% | 4658 | 913 | 98.4% | 19.2% | 4734 | 4761 | 49.9% | 50.1% |

These percentages suggest that the refined surface model and its definition of contrasting sensitivity zones are performing reasonably well, with the usual caveats concerning survey intensity and survey coverage.

For each of the watersheds, similar percentages of site-positive samples occur in the low- and high-sensitivity zones. The distribution of site-negative samples among watersheds is somewhat more variable. In the Santa Rosa Island, East Bay, and East Bay River watersheds, site-negative samples occurred on the order of 10% in the high-sensitivity zone. In the remaining watersheds, roughly 20% of site-negative samples occurred in the high-sensitivity zone. This suggests that the model, although of similar accuracy in each of the watersheds, is less precise in the Choctawhatchee Bay East, Choctawhatchee West, and Yellow River watersheds.

### 5.6.2 Fort Drum Sampling Results

The survey conducted on Fort Drum (red areas) and areas where STPs have been recorded (yellow areas) is shown in Figure 18. The red areas also include lands exempted from survey because they are inundated, inaccessible, or otherwise off-limits. To ensure that areas recorded in a GIS as surveyed parcels actually had been subjected to STP exploration, non-site samples were selected only from survey areas within which STPs are recorded in a GIS.

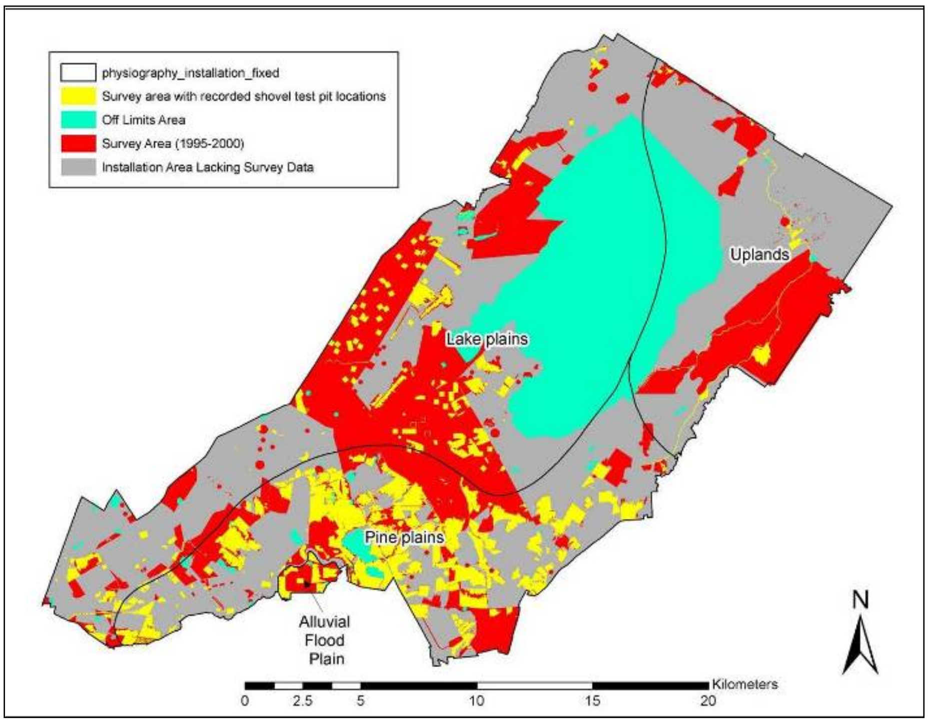


**Figure 18. Fort Drum survey areas (1995–2007) from which samples (STPs) could be selected for modeling purposes.**

Early survey (1995-2000) shown in red are areas without recorded STP locations.

The distribution of a sample of positive and negative surveyed locations with respect to the predictions of the Fort Drum refined surface model, which consists of low-, medium-, and high-sensitivity zones is presented in Table 7. The sample consists of roughly 27,000 samples derived

**Table 7. Distribution of positive and negative sample locations at Fort Drum and correspondence to predictions of the refined surface model.**

| Physiographic Zone | Low-Sensitivity Zone | | | | Medium-Sensitivity Zone | | | | High-Sensitivity Zone | | | | All-Sensitivity Zone | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Positive Samples | Negative Samples | % Total Positive Samples | % Total Negative Samples | Positive Samples | Negative Samples | % Total Positive Samples | % Total Negative Samples | Positive Samples | Negative Samples | % Total Positive Samples | % Total Negative Samples | Positive Samples | Negative Samples | % Total Positive Samples | % Total Negative Samples |
| Alluvial Flood Plain | 22 | 94 | 16.3% | 69.6% | 50 | 18 | 37.0% | 13.3% | 63 | 23 | 46.7% | 17.0% | 135 | 135 | 50.0% | 50.0% |
| Lake Plains | 139 | 1256 | 9.2% | 80.3% | 114 | 215 | 7.5% | 13.7% | 1260 | 93 | 83.3% | 5.9% | 1513 | 1564 | 49.2% | 50.8% |
| Pine Plains | 529 | 7793 | 4.6% | 67.4% | 2446 | 2433 | 21.1% | 21.1% | 8642 | 1331 | 74.4% | 11.5% | 11,617 | 11,557 | 50.1% | 49.9% |
| Upland | 13 | 166 | 5.4% | 65.4% | 48 | 45 | 19.8% | 17.7% | 181 | 43 | 74.8% | 16.9% | 242 | 254 | 48.8% | 51.2% |
| Total | 703 | 9309 | 5.2% | 68.9% | 2658 | 2711 | 19.7% | 20.1% | 10,146 | 1490 | 75.1% | 11.0% | 13,507 | 13,510 | 50.0% | 50.0% |

from surveyed areas, half of which contain a site; the remaining half of the sample consists of STP locations where a site has not been discovered. As would be expected, the majority of site-positive samples occurred within the medium- and high-sensitivity zones. Overall, three-quarters of site-positive samples occurred within the high-sensitivity zone and a fifth of site-positive samples occurred within the medium-sensitivity zone. The remaining 5% of site-positive samples occurred within the low-sensitivity zone.

Site-negative samples were predominantly located within the low-sensitivity zone. More than two-thirds of site-negative samples were located in the low-sensitivity zone and a fifth of site-negative samples occurred within the medium-sensitivity zone. Eleven percent of site-negative samples occurred within the high-sensitivity zone.

Variation occurs among physiographic zones in the distribution of positive and negative samples, according to sensitivity zone. These results for the Pine Plains and the Uplands are consistent with the overall distribution of site-positive samples with respect sensitivity zones, in large part because most samples for the lowland portion of the model come from the Pine Plains and the upland portion of the model was developed using samples for the Upland physiographic zone. The Lake Plains has a similarly high percentage of site-positive samples in the high-sensitivity zone, but low percentages of site-positive samples also occurred in the low-sensitivity and medium-sensitivity zones. The lowest percentage of site-positive samples in the high-sensitivity zone occurred in the Alluvial Flood Plain physiographic zone, where less than half of site-positive samples occurred in the high-sensitivity zone. This suggests that the model is less successful in identifying the high-sensitivity zone within surveyed areas of the Alluvial Flood Plain physiographic zone, placing a comparatively large percentage of site-positive samples in the low- and medium-sensitivity zones.

## 6.0 PERFORMANCE ASSESSMENT

As discussed in Section 5.2, the baselines for this demonstration are (1) predictive models prior to systematization, (2) performance of systematized predictive models prior to validation and refinement, and (3) CRM program performance prior to model integration. The performance of systematized, validated, and refined models in predicting site location will be assessed with reference to the baselines of (1) and (2) above, whereas the performance of CRM programs before and after model integration will be assessed with reference to (3). Discussed below is the analyses of data obtained during the demonstration for each of the performance objectives listed in Section 3.0. Additional details are provided in Table 8.

**Table 8. DoD installations selected for the ESTCP project.**

| DoD Installation | Armed Service | GIS Data Requirements for Validation of Surface and Subsurface Predictive Model(s) | Statistical Validation Tests | Performance Standards (S) |
|---|---|---|---|---|
| Fort Drum, NY | Army | **Environmental:** geomorphic data on paleoshorelines, fossil drainages, and fossil islands; soils; climate data; elevation (digital elevation model [DEM]); slope; aspect; hydrological boundaries; wetland coverage; terrace coverage; watercraft portage locations; economic plant distributions; and primary lithic sources.<br>**Cultural:** Survey areas; site polygons/centroids and site attributes; STP locational and attribute data. Data coverage requirements: (1) post-wide systematic sampling, (2) model testing, and (3) Section 106 actions.<br>**Predictive models:** GIS sensitivity maps and all GIS layers used to generate sensitivity maps. | **Modeling Approaches:** Logistic Regression and/or Weighted Intersection for Surface models; Paleolandscape Reconstruction through geomorphic analysis for Subsurface/Buried sites models<br>**Sampling Protocols for Independent Tests** (for Surface models only): Double Validation, Split-Sample and/or Jackknife<br>**Validation Tests** (for Surface models only): Gain and GOR statistics | **All-Sites Surface and Buried models:**<br>Overall: S≤0.39<br>High: S≈0.20<br>Medium: S≈0.75<br>Low: S≈14.0<br>**Red Flag model:**<br>Overall: S≤0.25<br>High: S≈0.13<br>Medium: S≈0.87<br>Low: S≈15.4<br>Positive gain values approaching 1.0<br>Positive GOR values approaching 100 |
| Eglin AFB, FL | Air Force | **Environmental:** potable water, DEM, physiographic zones (i.e., coastal and alluvial plains), Laser Imaging Detection and Ranging (LIDAR) data, and geomorphology.<br>**Cultural:** Survey areas; site polygons/centroids and site attributes; isolated find locations and attributes. Data coverage requirements: (1) base-wide random sampling and (2) Section 106 actions.<br>**Predictive models:** GIS sensitivity maps and all GIS layers used to generate sensitivity maps. | **Modeling Approaches:** Logistic Regression and/or Weighted Intersection for Surface models; Paleolandscape Reconstruction through geomorphic analysis for Subsurface/Buried sites models<br>**Sampling Protocols for Independent Tests** (for Surface models only): Double Validation, Split-Sample and/or Jackknife<br>**Validation Tests** (for Surface models only): Gain GOR statistics | **All-Sites Surface and Buried models:**<br>Overall: S≤0.39<br>High: S≈0.20<br>Medium: S≈0.75<br>Low: S≈14.0<br>**Red Flag model:**<br>Overall: S≤0.25<br>High: S≈0.13<br>Medium: S≈0.87<br>Low: S≈15.4<br>Positive gain values approaching 1.0<br>Positive GOR values approaching 100 |

## 6.1 IMPROVE ARCHAEOLOGICAL SURFACE PREDICTIVE MODELS

### 6.1.1 Sampling Protocols for Independent Tests

The sampling protocols described in Section 5.5 to build and validate predictive models have been published and are generally accepted within the archaeological community (Westcott and Brandon, 2000).

### 6.1.2 Validation Tests for Model Accuracy

Most predictive models generate probabilities of site detection for all land parcels in a study area. Typically, the probabilities are transformed into categorical variables summarized as high-, medium-, and low-sensitivity land parcels (Kvamme, 1990). Once sensitivity zones have been defined, the validation dataset (see below) can be used to evaluate the model results. This is done by evaluating the number of sites (or the total site area) found in each sensitivity zone according to the relative area of each sensitivity zone. Model validation is often performed using the Gain and GOR statistics.

> Gain=1–(percentage of total area covered by model/percentage of total sites within model area)
>
> As the Gain statistic approaches one (1), the model's predictive accuracy increases. A Gain Score near zero (0) means the model has little or no predictive utility beyond what could be gained through random chance. A negative Gain Score means the model performs worse than random chance.
>
> GOR = (percentage of sites within model area – percentage of area covered by model area)
>
> GOR ranges from -100 to +100. Negative index values reflect a model that works worse than random chance; low positive values reflect a model that works little better than random chance. High positive values reflect a model that accurately predicts site parcels within a relatively small model area.

The Gain and GOR statistics provide measures of overall model performance. They are relatively easy to compute and thus serve as useful initial measures. However, for a performance standard, a statistic that mirrors stakeholders' perceptions of what is acceptable model performance is needed. Altschul et al. (2004) designed the S to address this need.

> Si=(ai)/(bi) where ai is the proportion of sensitivity zone (i) surveyed to the total area surveyed, and bi is the proportion of the total number of sites that are found in sensitivity zone (i).
>
> Assuming at least one site is recorded in each sensitivity zone, S varies between zero and infinity. The closer S is to zero, the greater the sensitivity.

S is related to the Gain statistic, except that it calculates model performance for each sensitivity zone using all the available data, rather than using a random sample to calculate the performance of only the higher sensitivity zones. Because of this, we can use S to calculate the performance of high-, medium-, and low-sensitivity zones and evaluate performance according to standards agreed-upon by archaeologists and other stakeholders.

As described in Section 3.1.1, we adopted the MnModel standard for assessing performance of the all-surface sites and buried sites models (≥85% of sites within ≤33% of modeled area; S=0.39). The MnModel standard is a very conservative standard arrived at in Minnesota by stakeholder consensus. Installation personnel participating in the current project agreed to use the same conservative standard, although it is certainly possible for other standards to be applied in other situations. An even more conservative performance standard was adopted for red flag models as red flag sites are typically rare and require special management considerations not typically afforded to sites of other types. The standards adopted for assessing model performance, as well as the target values for individual sensitivity zones, are summarized in Table 8 (see also Table 1).

#### 6.1.2.1 Validation Tests for Eglin AFB Surface Models

To calculate the Gain and GOR statistics for the Eglin surface model, 100,000 random points were generated from within surveyed areas. The resulting points were then attributed in terms of whether they fell within a site area or a non-site area and according to the sensitivity zone where they were located for both the baseline surface model and the refined surface model. The numbers of points falling inside and outside sites and in the different sensitivity zones were then used as a proxy for area, because the points were generated randomly at a uniform density throughout surveyed areas.

The baseline surface model for Eglin AFB has only low- and high-sensitivity zones, and no medium-sensitivity zone, so the model area for the baseline model consists simply of the high-sensitivity zone, rather than medium- and high-sensitivity zones. For the baseline model, the Gain statistic was computed as 0.29 and the GOR statistic as 18.2 indicating that the model has predictive utility and performs better than random. For the refined surface model, the Gain statistic was computed as 0.70 and the GOR statistic was computed 69.3, indicating a substantial improvement over the baseline model in performance.

Sensitivity scores were calculated, as indicated above, using all the available data, rather than a random sample. Overall, the baseline model appears to work quite well, achieving an S of 0.46 (Table 9). Within just 29% of the installation area 62% of site acres were found, resulting in an S, which is relatively close to the MnModel standard of ≤0.39. It should be stated, however, that most survey for prehistoric sites since model development has been conducted in areas of high sensitivity; therefore, the sample of sites used to test the model could be biased towards those that occur mostly in high sensitivity zones of the baseline model.

**Table 9. Sensitivity scores for the Eglin AFB baseline surface model, according to watershed.**

| Watershed | Low-Sensitivity Zone | | | High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|
| | a | b | S | a | b | S |
| Barrier Island | 0.93 | 0.98 | *0.95* | 0.07 | 0.02 | *3.96* |
| Choctawhatchee Bay (west) | 0.72 | 0.28 | *2.62* | 0.28 | 0.72 | *0.38* |
| Choctawhatchee Bay (east) | 0.57 | 0.39 | *1.45* | 0.43 | 0.61 | *0.71* |
| East Bay | 0.80 | 0.35 | *2.26* | 0.20 | 0.65 | *0.32* |
| East Bay River | 0.77 | 0.33 | *2.31* | 0.23 | 0.67 | *0.35* |
| Yellow River | 0.77 | 0.35 | *2.22* | 0.23 | 0.65 | *0.35* |
| Entire Installation | 0.71 | 0.38 | *1.90* | 0.29 | 0.62 | *0.46* |

When tested according to watershed, it can be shown that model performance varies considerably among watersheds. Four of the six watersheds achieve an S of less than 0.39, but strictly speaking, none of the watersheds meet the MnModel performance standard established for the project (85% of sites within 33% of the modeled area).

Similar results were obtained when the baseline model was tested according to site type (Table 10). When the baseline model was tested for temporal affiliation (Table 11), only sites assigned to the earliest period (Paleoindian through Middle Archaic) met the Sensitivity Score of $\leq 0.39$.

**Table 10. Sensitivity scores for the Eglin AFB baseline surface model, according to site function.**

| Function | Low-Sensitivity Zone | | | High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|
| | **a** | **b** | **S** | **a** | **b** | **S** |
| Burial site | 0.71 | 0.00 | — | 0.29 | 1.00 | *0.28* |
| Campsite | 0.71 | 0.33 | *2.20* | 0.29 | 0.67 | *0.42* |
| Collection station | 0.71 | 0.24 | *2.92* | 0.29 | 0.76 | *0.38* |
| Mound site | 0.71 | 0.22 | *3.30* | 0.29 | 0.78 | *0.36* |
| Undetermined | 0.71 | 0.33 | *2.15* | 0.29 | 0.67 | *0.43* |
| Village/hamlet | 0.71 | 0.50 | *1.42* | 0.29 | 0.50 | *0.57* |

**Table 11. Sensitivity scores for the Eglin AFB baseline surface model, according to temporal affiliation.**

| Function | Low-Sensitivity Zone | | | High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|
| | **a** | **b** | **S** | **a** | **b** | **S** |
| Paleoindian through Middle Archaic | 0.71 | 0.26 | *2.73* | 0.29 | 0.74 | *0.39* |
| Late Archaic through Early Woodland | 0.71 | 0.39 | *1.84* | 0.29 | 0.61 | *0.47* |
| Middle and Late Woodland | 0.71 | 0.43 | *1.67* | 0.29 | 0.57 | *0.50* |
| Mississippian | 0.71 | 0.46 | *1.55* | 0.29 | 0.54 | *0.53* |
| Undetermined | 0.71 | 0.33 | *2.16* | 0.29 | 0.67 | *0.43* |

Like the baseline surface model, the refined surface model was tested according to watershed, site type, and temporal affiliation (Table 12, Table 13, and Table 14). The model correctly predicts over 98% of prehistoric site areas in just 17% of installation area. The refined model meets the MnModel standard for all watersheds according to the S as well as the underlying proportions that make up the S value. The model works least well for the eastern half of the Choctawhatchee Bay watershed, as was the case with the baseline model. Unlike the baseline model, the refined model also meets the MnModel standard for all site types and temporal affiliations, suggesting that it is not biased against particular kinds of resources.

**Table 12. Sensitivity scores for the Eglin AFB refined surface model, according to watershed.**

| Watershed | Low-Sensitivity Zone | | | High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|
| | a | b | S | a | b | S |
| Barrier Island | 0.84 | 0.02 | *50.81* | 0.16 | 0.98 | *0.16* |
| Choctawhatchee Bay (east) | 0.74 | 0.02 | *38.63* | 0.26 | 0.98 | *0.26* |
| Choctawhatchee Bay (west) | 0.83 | 0.01 | *59.77* | 0.17 | 0.99 | *0.17* |
| East Bay | 0.90 | 0.01 | *127.70* | 0.10 | 0.99 | *0.10* |
| East Bay River | 0.92 | 0.01 | *152.42* | 0.08 | 0.99 | *0.08* |
| Yellow River | 0.83 | 0.01 | *81.53* | 0.17 | 0.99 | *0.17* |
| Entire Installation | 0.83 | 0.01 | *55.76* | 0.17 | 0.99 | *0.17* |

**Table 13. Sensitivity scores for the Eglin AFB refined surface model, according to site function.**

| Function | Low-Sensitivity Zone | | | High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|
| | a | b | S | a | b | S |
| Burial site | 0.83 | 0.00 | — | 0.17 | 1.00 | *0.17* |
| Campsite | 0.83 | 0.02 | *51.73* | 0.17 | 0.98 | *0.17* |
| Collection station | 0.83 | 0.01 | *55.40* | 0.17 | 0.99 | *0.17* |
| Mound site | 0.83 | 0.00 | — | 0.17 | 1.00 | *0.17* |
| Undetermined | 0.83 | 0.02 | *39.97* | 0.17 | 0.98 | *0.18* |
| Village/hamlet | 0.83 | 0.00 | *551.00* | 0.17 | 1.00 | *0.17* |

**Table 14. Sensitivity scores for the Eglin AFB refined surface model, according to temporal affiliation.**

| Period | Low-Sensitivity Zone | | | High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|
| | a | b | S | a | b | S |
| Paleoindian through Middle Archaic | 0.83 | 0.01 | *92.34* | 0.17 | 0.99 | *0.17* |
| Late Archaic through Early Woodland | 0.83 | 0.00 | *283.06* | 0.17 | 1.00 | *0.17* |
| Middle and Late Woodland | 0.83 | 0.01 | *139.04* | 0.17 | 0.99 | *0.17* |
| Mississippian | 0.83 | 0.01 | *122.70* | 0.17 | 0.99 | *0.17* |
| Undetermined | 0.83 | 0.02 | *43.34* | 0.17 | 0.98 | *0.17* |

#### 6.1.2.2 <u>Validation Tests for Fort Drum Surface Models</u>

At Fort Drum, the Gain, GOR, and S statistics were calculated for the baseline and refined surface models (Table 15 and Table 16) following the same methods as applied to the Eglin AFB surface models.

**Table 15. Sensitivity scores for the Fort Drum glacial lake and upland baseline surface models, according to physiography.**

| Physiographic Zone | Low-Sensitivity Zone | | | Medium-Sensitivity Zone | | | High-Sensitivity Zone | | | Medium/High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | S | a | b | S | a | b | S | a | b | S |
| Alluvial Flood Plain | 1.00 | 1.00 | *1.00* | — | — | — | — | — | — | — | — | — |
| Lake Plains | 0.67 | 0.60 | *1.12* | 0.25 | 0.22 | *1.13* | 0.08 | 0.18 | *0.43* | 0.33 | 0.40 | *0.82* |
| Pine plains | — | — | — | 0.78 | 0.72 | *1.09* | 0.22 | 0.28 | *0.78* | 1.00 | 1.00 | *1.00* |
| Upland | 0.54 | 0.64 | *0.83* | 0.39 | 0.31 | *1.28* | 0.07 | 0.05 | *1.44* | 0.46 | 0.36 | *1.30* |
| Lowland combined | 0.44 | 0.07 | *6.25* | 0.44 | 0.66 | *0.66* | 0.13 | 0.27 | *0.47* | 0.56 | 0.93 | *0.61* |
| Entire installation | 0.46 | 0.08 | *5.81* | 0.43 | 0.65 | *0.65* | 0.11 | 0.27 | *0.43* | 0.54 | 0.92 | *0.59* |

**Table 16. Sensitivity scores for the refined surface model for Fort Drum, according to physiography.**

| Physiographic Zone | Low-Sensitivity Zone | | | Medium-Sensitivity Zone | | | High-Sensitivity Zone | | | Medium/High-Sensitivity Zone | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | S | a | b | S | a | b | S | a | b | S |
| Alluvial Flood Plain | 0.76 | 0.32 | *2.33* | 0.15 | 0.41 | *0.37* | 0.09 | 0.27 | *0.34* | 0.24 | 0.68 | *0.36* |
| Lake Plains | 0.86 | 0.13 | *6.75* | 0.09 | 0.12 | *0.77* | 0.05 | 0.75 | *0.06* | 0.14 | 0.87 | *0.16* |
| Pine plains | 0.75 | 0.12 | *6.07* | 0.16 | 0.31 | *0.50* | 0.09 | 0.57 | *0.16* | 0.25 | 0.88 | *0.28* |
| Upland | 0.47 | 0.11 | *4.36* | 0.21 | 0.47 | *0.45* | 0.32 | 0.42 | *0.76* | 0.53 | 0.89 | *0.60* |
| Lowland combined | 0.82 | 0.13 | *6.50* | 0.12 | 0.29 | *0.40* | 0.06 | 0.58 | *0.11* | 0.18 | 0.87 | *0.21* |
| Entire installation | 0.74 | 0.13 | *5.88* | 0.14 | 0.30 | *0.47* | 0.12 | 0.58 | *0.21* | 0.26 | 0.87 | *0.30* |

Gain and GOR statistics show that the baseline Glacial Lake Model (equivalent to the lowlands combined) has some potential as a predictive model. The Gain statistic was calculated as 0.34, indicating the model has predictive utility. At 31.4, the GOR statistic is low-to-moderate, suggesting that the model works better than random chance.

Evaluation of S values, however, indicates that the baseline Glacial Lake Model does not work particularly well in identifying medium- and high-sensitivity zones. This is mostly because these zones are large with respect to the size of the installation. Although the model correctly places roughly 93% of sites area within medium- or high-sensitivity zones, these zones together comprise approximately 56% of installation area. In other words, the model is accurate in where sites are likely to be found but in a fairly coarse-grained fashion. The model is not very precise or specific in identifying medium- or high-sensitivity zones. Where the model does work moderately well is in identifying areas of low sensitivity, given that sites are especially rare within the low-sensitivity zone.

The Upland Model performed poorly when tested with validation statistics. The Gain statistic was computed as -0.33 and the GOR statistic was computed as -11.0, indicating that the model has no predictive utility and performs worse than random. Approximately 64% of site area falls within the low-sensitivity zone, which comprises a little more than half of the Upland physiographic zone. S values indicate that both medium- and high-sensitivity zones perform worse than a random model, while the low-sensitivity zone has an S below 1, indicating that the proportion of site area within the low-sensitivity zone is higher than the proportion of installation

area in that zone. This outcome suggests that the low-sensitivity zone is actually more likely to contain sites than the medium- and high-sensitivity zones.

As with the refined surface model for Eglin AFB, the refined surface model for Fort Drum performs substantially better than the baseline models. The Gain statistic was calculated as 0.75 for the refined surface model, indicating the model has high predictive utility. At 66.5, the GOR statistic is also relatively high, indicating the model works substantially better than random. In other words, the Gain and GOR statistics for the refined model increased by a wide margin in comparison to the baseline models.

When tested with the S statistic, the overall refined surface model meets the MnModel standard, with 87% of site area occurring in medium-or high-sensitivity zones, which together comprise approximately 26% of the installation. However, the refined model does not work particularly well in the Upland physiographic zone. The refined model does meet the performance standard according to the S value and the underlying proportions that make up the S value for the Lake Plains and Pine Plains physiographic zones as well as for all lowland areas combined.

## 6.2 IMPROVE ARCHAEOLOGICAL SUBSURFACE PREDICTIVE MODELS

As with surface archaeological models, there are no nation- or discipline-wide standard for evaluating the accuracy or precision of models that predict the location of buried archaeological sites. Expectations based on the environmental attributes are improved (i.e., adjusted, recalibrated) by (1) actual discoveries of buried sites revealed through deep shovel tests, augers holes, and trenches, and (2) additional data on past landforms, climate, water resources, vegetation, and geomorphic processes.

In lieu of a widely acceptable standard, we suggest using the same S score value of 0.39, which represents 85% of all buried archaeological sites located in no more than 33% of the model area, to be our measure of success for the buried sites model. We were not able to obtain information other than anecdotal information on the location of buried sites at Eglin AFB or Fort Drum; the little information that we do have is insufficient to validate the subsurface model for either installation. We did use an alternate dataset to evaluation the subsurface model for Fort Drum.

Rather than randomly sampling the surveyed areas to calculate Gain and GOR statistics for the Fort Drum subsurface model, we used the sample of STPs (n=137,839) to identify STPs with potential buried cultural deposits (n=118). Using these data, the Gain statistic is calculated as 0.20, indicating that the model has low to moderate predictive utility, while the GOR statistic is calculated as 18.1, which suggests that the model predicts the location of buried cultural deposits better than random.

S values were calculated in the same manner as for the surface models, but using the STPs with potential buried cultural deposits in place of sites. Over 91% of STPs with potential buried cultural deposits were found within approximately 38% of the installation comprised of medium- and high-sensitivity zones. S values indicate that, overall, the subsurface model is close to meeting the performance objective, with an S of 0.42 for medium- and high-sensitivity zones. However, in examining the S values per sensitivity zone, it is clear that the model works well in

predicting the low- and medium-sensitivity zones ($S_{low}$=7.21; $S_{medium}$=0.40), but not as well as we would expect for the high- sensitivity zone ($S_{high}$=0.52).

## 6.3 IMPROVE ARCHAEOLOGICAL RED FLAG PREDICTIVE MODELS

No red flag models had been developed for either Fort Drum or Eglin AFB prior to the current project. As discussed earlier, a red flag model was created only for Eglin AFB because site type data were lacking for Fort Drum. The red flag model was tested with Gain and GOR statistics in the same manner as for the surface models, as well as tested with sensitivity scores. The Gain statistic for the red flag model was calculated as 0.95, indicating very high predictive capacity, and the GOR statistic was calculated as 94.8, indicating the model works much better than random. The exceptionally high performance of the model is likely due to the relatively concentrated and discrete locations in which red flag sites have been found, resulting in nearly all red flag-site area falling within a very small model area.

When tested with the Sensitivity Score statistic, the red flag model performs very well identifying 99% of red flag sites in just 3% of installation area. According to the model, red flag sites tend to be located near the coast adjacent to estuaries and inlets, on Santa Rosa Island, near the Yellow River, and near the headwaters of some streams in the interior of the installation.

## 6.4 DEVELOP SECTION 106 PROGRAMATIC AGREEMENTS BASED ON MODELING

As noted in Section 3.0 and Table 1, the metric for this objective was to complete a draft(s) and final version of the PA, based on consultation with installation stakeholders and Section-106 consulting parties. This objective was partially met for the demonstration project and will ultimately be met for the installations when the PA is executed and filed with the ACHP. As previously explained, the PAs for Eglin AFB and Fort Drum were prepared as final first drafts to provide each installation with a solid foundation on which to complete the consultation processes. These can be found in Appendices B and C.

## 6.5 STREAMLINE NATIONAL HISTORIC PRESERVATION ACT (SECTION 106) AND NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE

Given that the PAs for Eglin AFB and Fort Drum were not completed beyond first draft stage, we were unable to conduct the “before and after implementation” interviews with the CRM staffs concerning their perceptions of the Section 106 and NEPA compliance processes. We have, however, developed another approach to demonstrating the efficiency of developing and implementing predictive models of archaeological site location.

### 6.5.1 Reductions in Level of Effort, Cost, and Number of Sites Evaluated

The method used to illustrate these savings compares the time and money expended during routine activities when a model is implemented with hypothetical levels of effort and cost incurred when predictive models were not used to make planning or compliance decisions. To conduct this analysis, we assume that survey for prehistoric archaeological sites without benefit of a predictive model would be conducted in the same manner and at the same level of intensity for all areas of the installation. This is how most DoD installations conduct archaeological

survey if they do not have predictive models or do not employ some strategy for sample survey—all areas of an installation are treated as having equal potential for archaeological sites. Eglin AFB and Fort Drum, because they do have models in place and have been using them for planning and compliance purposes for many years, provide an opportunity for a “with and without” comparative analysis. Two scenarios for Eglin AFB are presented below, followed by Fort Drum. We also present a hypothetical scenario in which Eglin AFB could reduce the number of sites tested for National Register eligibility.

Two scenarios for Eglin AFB in which the time and costs of archaeological survey is compared using the baseline model and without the baseline model are presented in Table 17 and Table 18. Using Table 18, which likely is more realistic than Table 17, our scenario suggests that use of the baseline model will have saved Eglin AFB 63% in cost and time. The savings in cost and time achieved by Eglin AFB from using their archaeological predictive model far exceeds our 15% threshold for success. Looking to the future (Table 19 and Table 20), we illustrate how additional savings could be achieved by implementing the refined surface model in place of the baseline model. Future use of the refined model instead of the baseline model to complete survey could result in a savings of 60% in overall cost and time.

Using Table 21, our scenario suggests that use of the Glacial Lake baseline model has saved Fort Drum approximately 10% savings in cost and 8% savings in time, but neither exceed our 15% threshold for success. As with Eglin AFB, additional savings could be achieved by implementing the refined surface model in place of the baseline model. Using the refined model instead of the baseline model to complete future survey in the lowland portions of Fort Drum (Table 22), we show how a savings of 50% in both cost and time could be achieved.

A hypothetical scenario in which Eglin AFB samples three classes of archaeological sites with low information potential relative to larger, more complex sites such as village sites, burial sites, and mounds sites is presented in Table 23 through 26. In this scenario, Eglin AFB could achieve a savings of 64% in time and cost, far exceeding the 15%-threshold for success. This assumes that Eglin AFB will choose to adopt this or a similar approach and that the consulting parties to the Section 106-compliance process would agree. Nonetheless, as a comparative exercise we have demonstrated the potential for cost and time savings.

**Table 17. Eglin AFB, hypothetical scenario one, comparison of past performance with model versus without model using URS annual survey estimate.**
(see Table 4-4 and Table 4-8)

| Cost and Level of Effort | With Baseline Model | Without Model |
|---|---|---|
| **Past:** | | |
| Total reported surveyed and cleared acres (1994–2008)* | 193,981 | 193,981 |
| Total surveyed acres (1994–2008) calculated with GIS | 102,496.9 | 102,496.9 |
| Acres surveyed survey in low-sensitivity zone | 0.00 | 73,200.2 |
| Acres surveyed in the high-sensitivity zone | 102,496.9 | 29,296.7 |
| Cost per survey acre (1994-2008 15-yr average) | $62.33 | $62.33 |
| Total cost (1994–2008) | $6,388,632 | $6,388,632 |
| Cost for survey in low-sensitivity and cleared areas | $0.00 | $4,562,568 |
| Cost for survey in high-sensitivity zone | $6,388,632 | $1,826,063 |
| Survey acres per year | 12,932.1 | 12,932.1 |
| Time invested in survey (1994–2008) | 15.0 | 15.0 |
| Time savings with in-place model (yrs) [no low-sensitivity zone survey] | 5.7 | — |
| Cost savings with in-place model [no low-sensitivity zone survey] | $4,562,568 | — |
| **Future:** | | |
| Total acres remaining to be surveyed calculated with GIS for model | 30,461.5 | 259,147 |
| Acres surveyed in the low-sensitivity zone (or cleared) | 0 | 183,994 |
| Acres surveyed in the high-sensitivity zone | 30,461.5 | 75,153 |
| Cost per survey acre | $62.33 | $62.33 |
| Total survey cost (2009–?) | $1,898,665 | $16,152,633 |
| Cost for survey in low-sensitivity and cleared areas | $0.00 | $11,468,369 |
| Cost for survey in high-sensitivity zone | $1,898,665 | $4,684,263 |
| Survey acres per year (15-yr average) | 12,932.1 | 12,932.1 |
| Time required to complete survey (yrs) | 2.4 | 20.0 |
| Time savings with in-place model (yrs) [no low-sensitivity zone survey] | 14.2 | — |
| Cost savings with in-place model [no low-sensitivity zone survey] | $11,468,369 | — |
| **Full Cost (Past plus Future):** | | |
| Total cost with and without baseline predictive model: | $8,287,297 | $22,541,264 |
| Total time (yrs) with and without baseline predictive model | 17.4 | 35.0 |
| Time savings (percentage) using baseline model vs. using no model | 50% | — |
| Cost savings (percentage) using the baseline model vs. using no model | 63% | — |

*Acreage includes surveys conducted for historic-period homesteads, limited survey in low-sensitivity zones, and areas precluded from survey due to environmental or safety conditions.

**Table 18. Eglin AFB, hypothetical scenario 2, comparison of past performance with model versus without model, using GIS-Based annual survey estimate.**
(data derived from Table 4-4 and Table 4-8)

| Cost and Level of Effort | With Baseline Model | Without Model |
|---|---|---|
| **Past:** | | |
| Total reported surveyed and cleared acres (1994–2008)* | 193,981 | 193,981 |
| Total surveyed acres (1994–2008) calculated with GIS | 102,496.9 | 102,496.9 |
| Acres surveyed survey in low-sensitivity zone | 0.0 | 73,200.2 |
| Acres surveyed in the high-sensitivity zone | 102,496.9 | 29,296.7 |
| Cost per survey acre (1994–2008 15-yr average) | $62.33 | $62.33 |
| Total cost (1994–2008) | $6,388,632 | $6,388,632 |
| Cost for survey in low-sensitivity and cleared areas | $0.00 | $4,562,568 |
| Cost for survey in high-sensitivity zone | $6,388,632 | $1,826,063 |
| Survey acres per year (15-yr average calculated with GIS) | 6,833.1 | 6,833.1 |
| Time invested in survey (1994–2008) | 15.0 | 15.0 |
| Time savings with in-place model (yrs) [no low-sensitivity zone survey] | 10.7 | — |
| Cost savings with in-place model [no low-sensitivity zone survey] | $4,562,568 | — |
| **Future:** | | |
| Total acres remaining to be surveyed | 30,461.5 | 259,147 |
| Acres surveyed in the low-sensitivity zone (or cleared) | 0.0 | 183,994 |
| Acres surveyed in the high-sensitivity zone | 30,462 | 75,153 |
| Cost per survey acre | $62.33 | $62.33 |
| Total survey cost (2009–?) | $1,898,665 | $16,152,633 |
| Cost for survey in low-sensitivity and cleared areas | $0.00 | $11,468,369 |
| Cost for survey in high-sensitivity zone | $1,898,665 | $4,684,263 |
| Survey acres per year (15-yr average calculated with GIS) | 6,833.1 | 6,833.1 |
| Time required to complete survey (yrs) | 4.5 | 37.9 |
| Time savings with in-place model (yrs) [no low-sensitivity zone survey] | 33.5 | — |
| Cost savings with in-place model [no low-sensitivity zone survey] | $14,253,967 | — |
| **Full Cost (Past plus Future):** | | |
| Total inventory cost with and without baseline predictive model: | $8,287,297 | $22,541,264 |
| Total time (yrs) with and without baseline predictive model | 19.5 | 52.9 |
| Time savings (percentage) using baseline model vs. using no model | 63% | — |
| Cost savings (percentage) using the baseline model vs. using no model | 63% | — |

*Acreage includes surveys conducted for historic-period homesteads, limited survey in low-sensitivity zones, and areas precluded from survey due to environmental or safety conditions.

**Table 19. Eglin AFB, hypothetical scenario 1, comparison of future performance expectations using refined model versus baseline surface model using URS annual survey estimate.**

| Cost and Level of Effort | Refined Model | Baseline Model |
|---|---|---|
| Total acres remaining to be surveyed in high-sensitivity zone calculated with GIS | 12,227.9 | 30,461.5 |
| Cost per survey acre (1994–2008 15-yr average) | $62.33 | $62.33 |
| Survey acres per year (1994–2008 15-yr average) | 12,932.1 | 12,932.1 |
| Time Required to complete survey (yrs) | 0.9 | 2.4 |
| Cost to complete survey | $762,165 | $1,898,665 |
| Time savings using refined model (yrs) | 1.4 | — |
| Cost savings using refined model | $1,136,500 | — |
| Time saving percentage using refined model | 60% | — |
| Cost savings percent using the refined model | 60% | — |

**Table 20. Eglin AFB, hypothetical scenario 2, comparison of future performance expectations using refined model versus baseline surface model using GIS-based annual survey estimate.**

| Cost and Level of Effort | Refined Model | Baseline Model |
|---|---|---|
| Total acres remaining to be surveyed in high-sensitivity zone calculated with GIS | 12,227.90 | 30,461.5 |
| Cost per survey acre (1994–2008 15-yr average) | $62.33 | $62.33 |
| Survey acres per year (1994–2008 15-yr average) | 6,833.1 | 6,833.1 |
| Time required to complete survey (yrs) | 1.8 | 4.5 |
| Cost to complete survey | $762,165 | $1,898,665 |
| Time savings using refined model (yrs) | 2.7 | — |
| Cost savings using refined model | $1,136,500 | — |
| Time savings (percentage) using refined model | 60% | — |
| Cost savings (percentage) using the refined model | 60% | — |

**Table 21. Fort Drum, hypothetical scenario, comparison of past performance with model versus without model using GIS-based annual survey estimate.**

| Cost and Level of Effort | Baseline Model | Without Model |
|---|---|---|
| **Past:** | | |
| Total reported survey acres (2001–2007) | 5,322 | 5,322 |
| Total surveyed acres (2001–2007) calculated with GIS | 5,076.2 | 5,076.2 |
| Acres surveyed in low-sensitivity zone (2001–2007) | 585.8 (11.5%) | 2,213.2 (43.6%) |
| Acres surveyed in medium-sensitivity zone (2001–2007) | 3,536.6 (69.7%) | 2,218.3 (43.7%) |
| Acres surveyed in high-sensitivity zone (2001–2007) | 953.8 (18.8%) | 644.7 (12.7%) |
| Cost per survey acre (1994–2008 15-yr average) | $141.35 | $141.35 |
| Total cost (2001–2007) | $717,521 | $717,521 |
| Cost for survey in low-sensitivity zone (2001–2007) | $82,803 | $312,836 |
| Cost for survey in medium-sensitivity zone (2001–2007) | $499,898 | $313,557 |
| Cost for survey in high-sensitivity zone (2001–2007) | $134,820 | $91,128 |
| Survey acres per year (1994–2008 15-yr average) | 2,532.5 | 2,532.5 |
| Time invested in survey (2001–2007) | 7.0 | 7.0 |
| Time savings with in-place model (yrs) [no low-sensitivity zone survey] | 0.6 | — |
| Cost savings with in-place model [no low-sensitivity zone survey] | $230,033 | — |
| **Future:** | | |
| Total acres remaining to be surveyed (2008–?) calculated with GIS | 35,546.8 | 35,546.8 |
| Total acres in low-sensitivity zone | 4,087.9 (11.5%) | 15,462.9 (43.6%) |
| Total acres in medium-sensitivity zone | 24,776.1 (69.7%) | 15,534.0 (43.7%) |
| Total acres in high-sensitivity zone | 6,682.8 (18.8%) | 4,514.4 (12.7%) |
| Cost per survey acre (1994–2008 15-yr average) | $141.35 | $141.35 |
| Total survey cost (2008-?) | $4,446,718 | $5,024,540 |
| Survey acres per year (1994–2008 15-yr average) | 2,532.5 | 2,532.5 |
| Time required to complete survey (yrs) | 12.4 | 14.0 |
| Time savings with in-place model (yrs) [no low-sensitivity zone survey] | 4.5 | — |
| Cost savings with in-place model [no low-sensitivity zone survey] | $1,607,853 | — |
| **Full Cost (Past plus Future):** | | |
| Total survey cost with and without baseline predictive model | $5,164,239 | $5,742,061 |
| Total time (yrs) with and without baseline predictive model | 19.4 | 21.0 |
| Time savings (percentage) using baseline model vs. using no model [no low sensitivity] | 8% | — |
| Cost savings (percentage) using the baseline model vs. using no model | 10% | — |

**Table 22. Fort Drum, hypothetical scenario, comparison of future performance expectations with refined surface model versus baseline glacial lake model.**

| Cost and Level of Effort | Refined Model | Baseline Glacial Lake Model |
|---|---|---|
| Total acres remaining unsurveyed (2008?–?) | 35,546.9 | 35,546.9 |
| Total acres in low-sensitivity zone | 29,278.2 (82.4%) | 13,622.9 (38.3%) |
| Total acres in medium-sensitivity zone | 4,065.5 (11.4%) | 18,039.0 (50.7%) |
| Total acres in high-sensitivity zone | 2,203.2 (6.2%) | 3,884.9 (10.9%) |
| Total acres planned for survey (using a sampling plan) | 7,163.77 | 14,266.7 |
| Total acres planned for survey in low-sensitivity zone (10% of total) | 2,927.8 | 1,362.3 |
| Total acres planned for survey in medium-sensitivity zone (50% of total) | 2,032.8 | 9,019.5 |
| Total acres planned for survey in high-sensitivity zone (100% of total) | 2,203.2 | 3,884.9 |
| Cost per survey acre (1994–2008 15-yr average) | $141.35 | $141.35 |
| Survey acres per year (1994–2008 15-yr average) | 2,532.5 | 2,532.5 |
| Time required to complete Survey (yrs) | 2.8 | 5.6 |
| Cost to complete survey | $1,012,599 | $2,016,597 |
| Time savings using refined model (yrs) | 2.8 | — |
| Cost savings using refined model | $1,003,998 | — |
| Time savings (percentage) using refined model | 50% | — |
| Cost savings (percentage) using the refined model | 50% | — |

**Table 23. Numbers of sites according to function,* majority sensitivity zone, and the presence or absence of temporal data at Eglin AFB.**

| Function | Low-Sensitivity Zone | | Medium-Sensitivity Zone | | High-Sensitivity Zone | | Total Sites |
|---|---|---|---|---|---|---|---|
| | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | |
| Campsite or Collection Station | 44 | 34 | 10 | 9 | 20 | 14 | 131 |
| Undetermined | 12 | 67 | 0 | 19 | 15 | 10 | 123 |
| Total | 56 | 101 | 10 | 28 | 35 | 24 | 254 |

* Burial sites, Mound sites, and Village/Town sites are excluded.

**Table 24. Hypothetical site sample to be evaluated at Eglin AFB.**

| Function | Low-Sensitivity Zone | | Medium-Sensitivity Zone | | High–Sensitivity Zone | | Total Sites | % Sample |
|---|---|---|---|---|---|---|---|---|
| | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | | |
| Campsite or Collection Station | 22 | 9 | 5 | 3 | 10 | 4 | 53 | 40.5% |
| Undetermined | 6 | 17 | 0 | 5 | 8 | 3 | 39 | 31.7% |
| Total Sites | 28 | 26 | 5 | 8 | 18 | 7 | 92 | 36.2% |
| Percent Sample | 50.0% | 25.7% | 50.0% | 28.6% | 51.4% | 29.2% | 36.2% | |

**Table 25. Hypothetical site sample to be left in reserve at Eglin AFB.**

| Function | Low-Sensitivity Zone | | Medium-Sensitivity Zone | | High-Sensitivity Zone | | Total Sites | % Sample |
|---|---|---|---|---|---|---|---|---|
| | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | | |
| Campsite or Collection Station | 11 | 9 | 3 | 2 | 5 | 4 | 34 | 26.0% |
| Undetermined | 3 | 17 | 0 | 5 | 4 | 3 | 32 | 26.0% |
| Total Sites | 14 | 26 | 3 | 7 | 9 | 7 | 66 | 26.0% |
| Percent Sample | 25.0% | 25.7% | 30.0% | 25.0% | 25.7% | 29.2% | 26.0% | |

**Table 26. Hypothetical site sample to be left unevaluated and not placed in reserve at Eglin AFB.**

| Function | Low-Sensitivity Zone | | Medium-Sensitivity Zone | | High-Sensitivity Zone | | Total Sites | % Sample |
|---|---|---|---|---|---|---|---|---|
| | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | Temporal Data | No Temporal Data | | |
| Campsite or Collection Station | 11 | 16 | 2 | 4 | 5 | 6 | 44 | 33.6% |
| Undetermined | 3 | 33 | 0 | 9 | 3 | 4 | 52 | 42.3% |
| Total Sites | 14 | 49 | 2 | 13 | 8 | 10 | 96 | 37.8% |
| Percent Sample | 25.0% | 48.5% | 20.0% | 46.4% | 22.9% | 41.7% | 37.8% | |

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# 7.0 COST ASSESSMENT

## 7.1 COST MODEL

This section examines the expected operational costs for deploying the predictive models. The cost data presented in this section reflect our experiences with Eglin AFB and Fort Drum and the projected costs presented in Tables 17 through 22. The cost elements that were relevant to creating, validating, and refining the archaeological predictive models, and in developing the PAs that will be needed to streamline installation environmental compliance activities are listed in Table 27.

**Table 27. Cost model.**

| Cost Element | Data Tracked During the Demonstration |
|---|---|
| Create, validate, and refine surface model | Labor and material required |
| Create and validate red flag model | Labor and material required |
| Develop subsurface model | Labor and material required |
| Develop and implement PA | Labor and travel expenses |

Most of the costs associated with developing a predictive model are labor costs, with some additional costs for computers and software, purchases of digital data, and travel costs associated with field visits to installations. No digital data were purchased for this project, but it is possible that obtaining CRM data from state agencies for large areas can run into the thousands or even tens of thousands of dollars. For instance, to obtain existing archaeological data from state agencies for large areas can cost from thousands to tens of thousands of dollars. It should generally be the case, however, that DoD installations and ranges can obtain these data at little or no cost through cooperative agreements. Software licenses for GIS software will generally be available to installation staff, but if needed can be purchased costing thousands of dollars, depending on what capabilities are needed. If using ESRI Arc/GIS software for modeling, licenses for ArcView and Statistical Analyst will be minimum software requirements. The current prices for ArcGIS Version 10 software are $1500 for an individual ArcView license and $2500 for an individual Statistical Analyst license.

The exact costs for developing a predictive model will likely vary among installations and circumstances, depending on the size of an installation, an installation's modeling needs, the complexity of an installation's environment or culture history, data quality, and the variety of issues faced in obtaining and understanding CRM and environmental data. The effort to obtain and organize CRM and environmental data for modeling purposes as well as to develop model variables and samples for model construction represents a considerable investment that feeds into other modeling activities. Because of this, advantages are gained in later stages of the modeling process by initial investments in developing and organizing the underlying data. In addition, it should be acknowledged that creating, validating, and refining a model is part of an ongoing and iterative process and deciding where to begin and end that process is based on an installation's modeling needs.

Our experience with the ESTCP project and other modeling projects suggests that it costs approximately $100,000 to $120,000 to create, validate, and refine a surface model, with

approximately 70% of effort applied to creating a model, 10% of effort applied to validating the model, and 20% of effort applied to refining the model. The bulk of the investment stems from obtaining, organizing, and transforming data for model development and then analyzing those data to better understand the relationships among predictor variables and site location. Once these data have been developed and prepared for modeling purposes, other kinds of models, such as red flag models and subsurface models, can be more readily developed with less investment, since many of the underlying data have been already prepared and digested.

When many of the basic data are already prepared and modelers are familiar with the data, such as in the case where a surface model has been developed, the minimum cost of developing a red flag model is approximately $25,000. This is the cost of developing a red flag model in addition to a surface model when the data for the surface model have already been prepared and digested. The costs of developing a subsurface model for a project also involving the development of a surface model are somewhat larger than the costs for a red flag model due to the need for field visits and potentially greater investment of time and skilled labor. If the data have been prepared and digested for a surface model, the cost of creating a subsurface model is approximately $40,000.

However, if the development of a red flag model or a subsurface model was to be performed independently of developing a surface model, then the effort could be considerably more costly, due to the need to acquire digital data, CRM reports, and other information, and to organize and process the data so that they may be used for modeling. If a red flag model or a subsurface model was developed from scratch, with no prior investment, we might expect that the costs would increase substantially. The cost for developing a red flag model would be approximately $65,000, and the cost for developing a subsurface model would be approximately $80,000. In other words, we anticipate that it would cost an additional $40,000 to develop a red flag model or a subsurface model if the ground work for modeling had not already been established through the development of a surface model.

As discussed above, validation of surface models could be performed with existing CRM data obtained through routine installation activities. Validating a subsurface model, however, can require data that are obtained only through targeted field investigations involving the mechanical excavation of trenches or cores at depths exceeding those of typical STPs. Performing these kinds of field validation activities was outside the scope of this project. However, it is likely that such field validation efforts would minimally cost in the tens of thousands of dollars, depending on the nature of the effort. In all likelihood, it would be advisable to perform subsurface validation in conjunction with other installation efforts and as part of an effort to refine a subsurface model so that costs could be minimized and synergies achieved. Another way to validate subsurface models would be to maintain a database of all buried deposits discovered during the course of installation activities. Ideally, such a database would include the location, type, depth, integrity, and artifact or feature content of observed buried deposits, along with information on the project and excavation method from which the observation derives. Presumably, the development of such a database would allow subsurface models to be validated at a lower cost and without the need to implement larger projects specifically tailored towards subsurface model validation.

The costs associated with developing a PA are generally $25,000 to $30,000, depending on the nature of the compliance problems that must be solved and the time required to consult with all appropriate parties. Costs typically include: labor time required to consult with installation staff and other parties via meetings and conference calls, labor time needed to prepare review drafts, and travel expenses.

Assuming that the goal of developing an archaeological model includes a package of modeling tools consisting of a surface model, a red flag model, a subsurface model, as well as a PA to operationalize the use of these models for compliance purposes, it is estimated that the total cost will be in the range of $215,000 plus-or-minus $10,000. Development of the individual models in this package will increase the costs by at least $30,000 not including the cost of developing the PA.

## 7.2 COST DRIVERS

Labor, materials, and travel expenses can all be expected to rise in the future by at least 3% per year. As discussed above, these are the principle costs associated with developing and implementing predictive models at DoD installations.

## 7.3 COST ANALYSIS AND COMPARISON

The only alternative methodology to CRM compliance that we can compare to a programmatic, predictive modeling approach is the current project-by-project method employed by DoD installations to fulfill their respective environmental compliance responsibilities. As noted above, the two demonstration installations (Eglin AFB and Fort Drum) do not track the labor or material costs expended in their compliance activities. It is not possible, therefore, to compare the use of archaeological predictive modeling directly with a project-by-project approach or with any other potential alternative methodology. However, as presented in Section 6.0, it is possible to provide summary statistics comparing the use of archaeological predictive models against survey conducted following standard operating procedures without such models at Eglin AFB and Fort Drum.

Current methods of recording archaeological sites require on-the-ground pedestrian survey by a team of archaeologists who are spaced apart at a standard interval (e.g., 15 m). The survey team traverses the landscape recording all cultural resources 50 years old or older within the survey transects. Typically excluded are areas heavily disturbed by past development, slopes not conducive to human habitation (e.g., 15% or greater), and any area that is not safely accessible, such as firing ranges with unexploded ordnance (UXO). In the absence of a sampling strategy or predictive model, 100% of the installation is investigated in this manner, which can involve intensive labor and high associated costs. The following tables compare level of effort for archaeological survey using archaeological predictive models versus standard survey methods without models at Eglin AFB and Fort Drum.

A comparison of cost and time (level of effort) invested in archaeological survey at Eglin AFB using the baseline model versus not using the model, both employing standard survey methods (see Table 18) is presented in Table 28. Summary figures are presented for past survey costs and time invested, projected costs and years needed to complete survey, as well as total costs and

time combining past and future levels of effort. In sum, Eglin AFB has invested $6,388,632 over 15 years to identify and manage its archaeological resources. Using the baseline model, Eglin AFB will require an additional $1,898,665 and 4.5 years to complete survey of the remaining acres in the high-sensitivity zone. The total estimated costs for archaeological survey from beginning to end are $8,287,297 over a 19.5-year period. In contrast, the level of effort needed to complete the work without the model is considerably higher. Unless future survey is limited to the high-sensitivity zone, all remaining acreage at Eglin AFB will need to be surveyed to meet federal regulations and U.S. Air Force requirements. Estimated cost to complete inventory of the installation following standard survey methods is $16,152,633 requiring an additional 37.9 years. Total projected cost of archaeological survey at Eglin AFB without using the baseline model is $22,541,264 requiring 52.9 years. The savings in time and money achieved by using the baseline model over not using a model is 63%.

**Table 28. Summary of level of effort at Eglin AFB with and without baseline model.**
(see Table 18)

| Cost and Level of Effort | With Baseline Model | Without Model |
|---|---|---|
| **Past:** | | |
| Total survey cost (1994–2008) | $6,388,632 | $6,388,632 |
| Time (years) invested in survey (1994–2008) | 15.0 | 15.0 |
| **Future:** | | |
| Total survey cost (2009–?) | $1,898,665 | $16,152,633 |
| Time required to complete survey (yrs) | 4.5 | 37.9 |
| **Full Cost (Past plus Future):** | | |
| Projected total survey cost with/without baseline model | $8,287,297 | $22,541,264 |
| Projected total time (years) with/without baseline model | 19.5 | 52.9 |
| Projected cost savings (percentage) using baseline model | 63% | — |
| Projected time savings (percentage) using baseline model | 63% | — |

The level of effort estimates for the baseline model and the refined model (see Table 20) are compared in Table 29. With the baseline model, Eglin AFB will still need to expend an additional $1,898,655 to complete survey of the high-sensitivity zone requiring 4.5 more years of archaeological survey. If Eglin CRM managers used the refined model instead of the baseline model (without figuring in the cost of developing and implementing the model), these same expenditures could be reduced to $762,165 and 1.8 years respectively. The approximate cost of developing and implementing a predictive model is $215,000. The total cost of developing and using the refined model then would be approximately $977,165. In short, using the refined model would save Eglin about $921,500 ($1,898,665 - $977,165) and 2.7 years of work, representing a 49% savings in cost and a 60% savings in time.

**Table 29. Summary of level of effort for future survey at Eglin AFB using refined surface model versus baseline model.**
(see Table 20)

| Cost and Level of Effort | Refined Surface Model | Baseline Model |
|---|---|---|
| Cost required to complete survey | $762,165 | $1,898,665 |
| Time required to complete survey (yrs) | 1.8 | 4.5 |
| Cost of model development and implementation | ~$215,000 | — |
| Projected cost savings using refined surface model | ~$921,500 | — |
| Projected time savings using refined surface model (yrs) | 2.7 | — |
| Projected cost savings (percentage) using refined surface model | 49% | — |
| Projected time savings (percentage) using refined surface model | 60% | — |

The estimated cost and time investments for using the baseline model to the end of the demonstration period (2008) together with the refined model for all future survey and compares these figures to the total level of effort without either model (see Table 28 and Table 29) are presented in Table 30. As presented, the cost and time differences are significant. Using the baseline and refined models together, the level of effort can be limited to $7,365,797 and 16.8 years, compared to $22,541,264 and 52.9 years, representing a total cost savings of 67% and time savings of 68% over using the existing baseline model.

**Table 30. Comparison of projected total level of effort at Eglin AFB using past baseline and future refined surface models versus using no models.**

| Cost and Level of Effort | With Models | Without Models |
|---|---|---|
| Projected cost using past baseline + future refined surface models vs. using no model | $7,365,797 | $22,541,264 |
| Projected time (yrs) using past baseline + future refined surface models vs. using no model | 16.8 | 52.9 |
| Projected cost savings (percentage) using the baseline model + refined model | 67% | — |
| Projected time savings (percentage) using baseline model + refined surface model | 68% | — |

Information on cost and time invested in archaeological survey at Fort Drum, using the baseline model versus not using the model (see Table 21) is summarized in Table 31. This comparison looks at past expenditures in time and money, projects future levels of effort needed to finish survey at Fort Drum, and then adds both calculations to provide a total figure for survey level of effort. Fort Drum has invested $717,521 in archaeological survey over a 7-year period. It is estimated that to complete the survey an additional $4,446,718 will be needed using the model and $5,024,540 without the model. With the baseline model the survey can be finished in 12.4 years and without the model in 14.0 years. The full cost of survey from beginning to end indicates that using the baseline model Fort Drum can save $577,822 or 1.6 years representing a cost savings of 10% and a time savings of 8%.

**Table 31. Summary of level of effort at Fort Drum with and without baseline model.**
(see Table 22)

| Cost and Level of Effort | With Baseline Model | Without Model |
|---|---|---|
| **Past:** | | |
| Total survey cost (2001–2007) | $717,521 | $717,521 |
| Time (yrs) invested in survey (2001–2007) | 7.0 | 7.0 |
| **Future:** | | |
| Total survey cost (2008–?) | $4,446,718 | $5,024,540 |
| Time required to complete survey (yrs) | 12.4 | 14.0 |
| **Full Cost (Past plus Future):** | | |
| Projected total survey cost with/without baseline model | $5,164,239 | $5,742,061 |
| Projected total time (yrs) with/without baseline model | 19.4 | 21.0 |
| Projected cost savings (percentage) using baseline model | 10% | — |
| Projected time savings (percentage) using baseline model | 8% | — |

A summary of information on level of effort for future survey using the refined model compared to the baseline Glacial Lake Model (see Table 22) is provided in Table 32. Using the existing baseline model, Fort Drum can expect to pay an additional $2,016,597 to complete the archaeological survey in about 5.6 years. If Fort Drum were to use the refined surface model instead of the baseline Glacial Lake model, these expenses could be reduced to $1,012,599 and 2.8 years respectively. The approximate cost of developing and implementing a predictive model is $215,000. The total cost of developing and using the refined model then would be $1,227,599, representing a savings of $788,998 or about 39% in overall costs and about half the total time over using the baseline Glacial Lake Model.

**Table 32. Summary of level of effort for future survey at Fort Drum using refined surface model versus baseline glacial lake model.**
(see Table 22)

| Cost and Level of Effort | Refined Surface Model | Glacial Lake Baseline Model |
|---|---|---|
| Cost required to complete survey | $1,012,599 | $2,016,597 |
| Time required to complete survey (yrs) | 2.8 | 5.6 |
| Cost of model development and implementation | $215,000 | |
| Projected cost savings using refined surface model | $788,998 | — |
| Projected time savings using refined surface model (yrs) | 2.8 | — |
| Projected cost savings (percentage) using refined surface model | 39% | — |
| Projected time savings (percentage) using refined surface model | 50% | — |

Lastly, Table 33 compares the projected level of effort invested in archaeological survey from beginning to end using the baseline and the refined model versus not using models to present a comprehensive picture of total expected savings (see Table 31 and Table 32). Without the models, Fort Drum can expect to have paid $5,742,061 to complete archaeological survey over a 21.0-year period. By investing in the development of refined model, and using the baseline model up until the end of the demonstration period (2008) and then switching to the refined model, Fort Drum could complete its remaining archaeological survey requirements for $1,227,599 over a total of 2.8 years. This would result in a total installation inventory cost of

$1,945,120 ($717,521 + 1,012,599 + $215,000) over 9.8 years, representing a saving of 66% in cost and 58% in time.

**Table 33. Comparison of projected total level of effort at Fort Drum using past baseline and future refined surface models versus using no model.**

| Cost and Level of Effort | With Models | Without Models |
|---|---|---|
| Projected total cost using past baseline + future refined surface models vs. using no model | $1,945,120 | $5,742,061 |
| Projected total time (yrs) using past baseline + future refined surface models vs. using no model | 9.8 | 21.0 |
| Projected cost savings (percentage) using the baseline model + refined model | 66% | — |
| Projected time savings (percentage) using baseline model + refined surface model | 58% | — |

In summary, the project has demonstrated that Eglin AFB has developed an effective baseline archaeological predictive model that has worked well over many years. With the refinements made to the baseline model, performance is expected to increase, resulting in additional savings in time and money. Without the use of either the baseline model in the past or the refined model in the future, Eglin AFB would have been faced with more than five decades of survey work costing more than $22 million. The savings at Fort Drum are not as extreme. Nonetheless, our estimates indicate, however, that by applying the refined model rather than the Glacial Lake baseline model to guide where future archaeological survey is conducted, Fort Drum will achieve savings of about $789,000 and approximately three years in survey time. Without the use of either baseline model or refined model, Fort Drum would have spent more than $5.7 million and taken more than two decades to address its site inventory requirements.

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# 8.0 IMPLEMENTATION ISSUES

Seven overarching issues related to predictive modeling for military installations emerged during the course of our ESTCP demonstration project. These issues include: (1) the availability of data required to develop, test, and refine predictive models; (2) the need for standardization and explicit protocols related to archaeological survey and data recovery; (3) the recognition that modeling is an iterative process; (4) the usefulness of developing models for buried archaeological sites; (5) the necessity of developing a variety of predictive models to address CRM compliance responsibilities; (6) the effectiveness of PAs to streamline compliance; and (7) the importance of early consultation in the development of a PA. Each issue is briefly described below**.**

## 8.1 OVERARCHING ISSUES

1. *Transmitting, organizing, and evaluating CRM data for modeling can require considerable effort for both installations and modelers.*

Developing predictive models requires a large quantity of CRM and environmental data. Although many installations have compiled some of these data, they often are not readily available in a digital format. Reports describing the results of CRM investigations and providing information on methodology and culture history frequently will be needed to understand the data, and large volumes of data may need to be transmitted on external hard drives. Sometimes, in excess of a terabyte of data will need to be transmitted for use in modeling**—**a constraint which can sometimes pose logistical challenges for an installation.

When they are available, digital data may require extensive evaluation for data quality and representativeness. For instance, it is often the case that CRM site attribute data are scattered across multiple databases, tables, and fields, and that the data entered in a given field are recorded as unstandardized comments, making their interpretation difficult. Similarly, it is not uncommon for identical mapping features (e.g., a survey polygon feature or a STP point feature) to be duplicated multiple times within a GIS layer as a result identical polygon or point data being merged into a master shapefile for survey areas, site areas, or test locations, resulting in multiple copies of the same data. These erroneously duplicated features may need to be cleaned up in order to avoid over-counting features during analysis. There may also be problems with the topology of polygons; mismatches between the attributes of mapping features in a GIS and the same features recorded in an independent attribute database; inaccurate or unspecified datum and projection information; missing data; a lack of congruence between layers in the extent and shape of common features; and many other problems. These problems need to be resolved in order to use CRM data or environmental data appropriately for modeling.

Along with CRM data, environmental data need to be obtained and processed to develop predictor variables for modeling. Installations will often have some environmental data that have been developed in-house. These kinds of data can be very useful as they may be relatively fine-grained and installation-specific, but understanding the source of the data and how the data were developed will be important in order to use them effectively. It may be necessary to have access to any reporting materials associated with the data as well as metadata in order to apply the data in modeling.

Publicly-available national mapping datasets—such as digital elevation data, vegetation data, hydrographic data, and soils data—will often comprise the primary data for deriving many predictor variables, but these, too, need to be examined closely for possible problems. For instance, National Elevation Dataset data are increasingly available at cell sizes of 10 m or less, but care will need to be taken in understanding the underlying sources of the contributing elevation data. Currently, many elevation datasets are derived from sources obtained at multiple resolutions, such as a combination of 10 m and 30 m cell size datasets, and then resampled to the smaller cell size. The process of bringing these elevation datasets together at a common resolution can introduce unwanted noise, or "digital artifacts," into the dataset. These artifacts of the process of combining datasets are not apparent when viewing the untransformed dataset, but can become more apparent when derivative layers, such as slope or flow accumulation, are derived from such layers. For instance, linear bands often show up in derivative layers and these can skew the results of a transformation enough to make the dataset unusable. In such cases, using a more coarse-grained dataset may be desirable in order to obtain usable results.

Once these kinds of problems have been resolved, environmental layers need to be projected into a common datum and projection system in order to be used in modeling. It is often the case that all layers used in modeling will need to cover the exact same extent and use the same units, datum, and projection system. Since most predictive modeling efforts are conducted within a raster environment, polygon and point layers used to create predictor variables need to be converted to raster cell grids. Grids need to be resampled as necessary to a common grid, such that each grid cell in each mapping layer overlaps precisely with the grid cells of the other mapping layers. Depending on the complexity of operations needed to develop a predictor variable layer, many steps can be required in order to derive the desired variable. The processing time for developing individual layers can sometimes take hours or days to complete, depending on the complexity of the algorithm used and the extent and resolution of the dataset.

Once CRM data and environmental layers are organized and processed, relationships among cultural resources and variables will need to be assessed to determine whether variables are intercorrelated and which variables have the strongest potential to predict site location. As a result of these assessments, it may be the case that variables will need to be refined and composite variables will need to be developed through methods such as principal components analysis to reduce intercorrelations among variables.

In short, before an actual model is developed a large amount of time and effort is needed to organize, transmit, process, and explore CRM and environmental data. These activities can require a considerable investment of time and effort for both modelers and installation staff. One can expect that it will generally take at least several months to acquire the core data from installations, and it may be necessary for project staff to visit an installation and work directly with installation staff in order to obtain the necessary data. Given the limited time and resources that installation staff has available for such activities, obtaining the necessary data can be a strain on an installation. We recommend that time and resources be devoted to an installation to help them prepare data and work with modelers to transmit data and related information needed to understand the data. It would also be advisable for installations to organize and validate their CRM data according to an agency-wide set of data quality standards.

2. *Installations should endeavor to develop a core set of validated attributes for survey areas, test units, and recorded sites in order to facilitate modeling.*

There is a variety of common attributes that greatly facilitate modeling, but it is generally the case that relevant attributes are not readily available in a digital format. When such attributes are available, they may be available only in a spotty, incomplete, or unstandardized fashion. This situation is understandable, as many installations develop these data incrementally as time and resources permit. Moreover, an installation may not have had the time or resources to develop a comprehensive database structure or explicit protocols for data entry. Even in the best of circumstances, installations will not have developed digital attribute data with activities such as predictive modeling in mind.

In a report on archaeological data quality in the military, Heilen et al. (2008) found that many attribute data that could be used to assess CRM data quality on military installations were not commonly available. In that report, Heilen et al. (2008) recommended maintaining detailed digital data on survey and site recording methods as well as conditions during survey that could have affected results, such as archaeological visibility. These same kinds of data would be useful for predictive modeling in order to evaluate data quality. Other kinds of data that would be useful for predictive modeling would be standardized data that could be used to organize sites and isolate into types, including information on function and cultural and temporal affiliation, as well as information on artifact and feature counts and types. In addition, it would be useful to maintain data on the pedological horizons and artifact content of test units as Fort Drum has done, and temporal data on when survey and site recording or rerecording were conducted. Many installations have some of these data in some form in their CRM database, but the data are often incomplete or entered in an unstandardized fashion across multiple fields.

Having these standardized data available so they can be clearly and unambiguously associated with site and survey polygons and other mapping features would not only greatly facilitate modeling efforts, but also would make greater use of data that the DoD has spent a great deal of time and money developing. Not using these data effectively or not maintaining them within a common and easily interpretable database environment erodes their potential usefulness. On the other hand, making these data available digitally in a standardized format would not only leverage their usefulness to multiple ends, but also would help installations identify data gaps and better understand the kinds of data they should be developing during current and future installation tasks.

3. *Installations will need to plan funding for testing and refining models on a periodic basis. Include as commitment in PAs.*

Modeling is a process, not an event. Models that are left as static maps lose their usefulness over time and become increasingly outdated as new data are developed. In order to be useful and to maintain stakeholder buy-in, models should be tested on a periodic basis and refined with new data, refined variables, or alternate modeling approaches, as warranted. Ensuring that a model is a dynamic product that can be updated with new information and that responds to the changing needs of an installation helps to maintain the use-life of a model as well as shows that an installation is responsive to stakeholder concerns and current research directions. As a

consequence, installations need to make sure that funds are planned on a periodic basis to revisit models, test how well they perform in light of new data, and refine models as appropriate. To ensure that periodic testing and refinement occurs and that funds are available to do so, it is advisable that these activities be included as a commitment in PAs.

4. *Testing and refinement of subsurface models will require methods specifically tailored to the discovery of buried sites.*

Buried sites are not commonly discovered through routine site discovery techniques, often because pedestrian survey or STPs do not adequately expose buried deposits to the extent that they can be recognized. The limited exposures resulting from routine discovery techniques are generally inadequate for feature manifestations or artifacts within buried deposits to be observed. Moreover, specific kinds of depositional environments (such as alluvial flood plains, aeolian dune formations, or wetland margins) may need to be specifically targeted for testing, even if they fall outside current impact areas. Most importantly, excavation strategies involving trenching or coring will likely be necessary to test for buried deposits in these environments. As a result, the full validation of a subsurface model, as well as its refinement, may require a geoarchaeological investigation to be conducted specifically for that purpose. As discussed earlier in this report, it may also be useful to compile information on buried deposits observed during routine investigations as well as during construction activities. In such cases, it is advisable to employ a geoarchaeologist to document exposures of potential buried deposits encountered during construction activities and to develop a comprehensive database to record these findings.

5. *The needs of installations change, requiring a flexible approach to the kinds of models used now and in the future.*

Not all installations need models of archaeological site location. There are many kinds of models that can be developed and these should be developed to address the current and anticipated needs of an installation's CRM program. For instance, an installation may have largely completed inventory, but may need a model to assess the adequacy of previous survey in order to decide which areas of the installation, if any, are in need of resurvey. Similarly, an installation may need a model to help decide which sites to test for National Register evaluations or to place sites into different significance categories. Alternatively, an installation may need a model to project where TCPs are likely to occur. Installations may also need models to assess what impacts to sites are likely in the future as a result of planned construction projects or the effects of climate change. In short, there is no one single kind of model that every installation needs; the right model(s) for an installation need to be developed through careful examination of the questions and concerns that need to be addressed and compilation of the data and methods relevant to answering those questions.

6. *Modeling and PA development should be conducted in close communication with consulting parties.*

The overarching goal of this demonstration was to show that using archaeological predictive modeling can aide DoD installations in streamlining their CRM planning and compliance

functions. To meet the requirements of NHPA Section 106, and by extension NEPA, DoD installations must be able to use predictive models on a daily basis. The regulations implementing Section 106 make provisions for tailoring the compliance process to meet the needs of federal agencies through PAs. These agreements are negotiated between federal agencies and consulting parties, such as Indian tribes, historical societies, and local museum organizations, that have a legal interest in or concern about the potential effects of federal undertakings on historic properties. The project team understood that PAs would have to be developed to harness the utility of predictive models in the Section 106 compliance process, and this would require working with the consulting parties to explain how models can be used to better manage archaeological resources. Developing and implementing predictive archaeological models to meet future Section 106 compliance needs at other DoD installations will require the same effort. Multiple meetings with an installation's CRM staff and consulting parties, supplemented by conference calls as needed, will be required from the beginning of the project to its end. It is advisable to hold a final meeting in which the model or models are presented and demonstrated using real-world examples specific to the installation.

*7. PA drafting should begin at the point models can be explained in operational detail.*

As mentioned above, PAs are tools for achieving Section 106 compliance that meet the needs of federal agencies; this is done in consultation with other parties. Coordinating the developing of archaeological predictive models and the consultation process needed to prepare a PA is essential. Consultation should begin at the earliest stage in the project's development in order to explain to the consulting parties the purpose of the modeling and the project goals. The consulting parties need to be comfortable with the idea of modeling and have a basic understanding of what to expect from the modeling process. Although this early stage in the process is an opportunity to discuss a PA in general terms, drafting the PA should begin when the modeling is advanced to the stage where preliminary results can be presented. Up until that point, the modeling project will be an abstraction lacking in operational detail. After this point, however, the focus of discussion can shift to a real-world application. Consulting parties will want to know that the model or models are meeting the stated goals. Their ultimate concerns will be about the accuracy and reliability of the model or models when applied to real-world problems in CRM. As the modeling progresses, development of the PA can address operational detail on when and under what circumstances the model will be used. The PA should be completed after the modeling is concluded and a final project presentation is made to installation staff and the consulting parties.

## 8.2 LESSONS LEARNED

Four key lessons emerged from the ESTCP project. They range from technical issues surrounding data to human relations.

*1. It is modeling, not models*: Traditionally, predictive models have been created as stand-alone features. Installations and ranges expend substantial money and time to create the best model of archaeological site location at the time. These models are placed on the shelf or, in the case of a map, on the wall. They are rarely tested or kept up-to-date. The model may be referenced when projects are planned, providing planners with a sense of what may be expected and, occasionally, a rationale for altering the design of the project.

Our human ancestors did not use the landscape in random manner. They logically situated themselves in relation to resources and other social groups. It follows, therefore, that the more land we survey, the better our ability to discern those places favored in the past from those that were shunned. Predictive models will get better with additional data. Perhaps our best measure of knowledge about archaeological site location is the rate at which model predictions improve. A vastly improving model shows that we need to continue to survey, whereas a model whose predictive power remains the same as more data are incorporated suggests that the patterns in ancient settlement that can be discerned by our survey methods are well established.

It is our recommendation that DoD commit to modeling and not models. Part of the difficulty with predictive modeling in the past is that the commitment to maintain them requires specialized expertise and resources not generally available at the installation level. Currently, front-end software can be written that link site databases with predictive modeling algorithms so that models can be updated as archaeological are entered. With a modest investment, therefore, predictive modeling does not have to require specialized expertise, but can be easily incorporated into the flow of an installation's CRM program.

*2. Garbage in, garbage out: quality in, quality out*: At the four demonstration sites, the weakest link in the installation's CRM programs ability to model was the quality of the data in the installation's database. For the most part, installations maintain data on archaeological sites relative to location, size, and gross time category (i.e., prehistoric versus historical period). Resulting models combined all sites from all periods (with the possible exception of historical-period sites). Given that many different cultures and adaptations are mixed in the data, the resulting models are often poor predictors of site location. These models generally predict the locations of site types encompassing the largest areas the best and are poor predictors of rare site types. Unfortunately, the latter tend to be the ones in which stakeholders have the most interest and greatest concerns.

Much of the data needed to refine models to site type and time period are routinely collected during archaeological surveys. These data, however, are commonly not entered in installation databases because of the effort needed to code and enter them combined with the fact that these data are not normally needed in routine day-to-day CRM decisions. DoD is sitting on a wealth of data, which the agency has collected at considerable cost and effort. It may surprise many that the best way to improve predictive modeling is not collecting more data, but using data that has already been collected. We note that progress in the development of enterprise-wide relational databases for use in CRM is uneven across the military services. One attempt was made in DoD in the 1990s, as part of the Defense Environmental Security Corporate Information Management (DESCIM) program. Cultural resources were to be treated in a late module, but the program was terminated in 2000 with no action in that regard. Most recently, DoD encouraged the revision of the geospatial data standards for cultural resources in its update of the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) 3.0. Likewise, business data standards for cultural resources were revised as a follow-on effort and presented to the services for implementation. This remains a work in progress, and it will retard the corporate implantation of modeling at all echelons until established.

*3. All together now*: The biggest hurdles facing predictive modeling are not technological, they are sociological. Predictive models have been used in CRM for more than 30 years. Most agencies have tried to use models to lessen the amount of inventory by arguing that survey is not needed in low-sensitivity areas. The backlash led by tribes, SHPOs, and other archaeologists was swift. They argued that we do not know enough to have confidence in models and that sites will inevitably be lost. Many stakeholders remain both skeptical of models and skeptical of government agency motives in promoting models.

It would be a mistake for DoD as a federal agency or a military installation on its own to decide to incorporate predictive modeling in its CRM compliance. Such a move would feed into the skepticism that SHPOs, tribes, and others already have toward predictive modeling. The best way to move forward is to make predictive modeling a joint effort from the very beginning. Fort Drum is a case in point. Prior to this ESTCP demonstration project, the New York SHPO was strongly opposed to predictive modeling. Before initiating the demonstration project, the demonstration project team met with SHPO representatives and discussed the latter's concerns, how to meet them, and how to move forward. The project team provided the SHPO with a demonstration of the model and was in regular contact with them as the PA was drafted. The consultation required considerable effort. We are convinced, however, that without this effort, no model, regardless of how accurate and powerful, would have allayed SHPO concerns and that a programmatic approach could not be successfully implemented.

*4. Modeling is not an option*: The decision to develop a predictive model or to have no model is a false choice. Without a model, an installation archaeologist falls back on his or her accumulated knowledge of site location. Decisions to survey or not to survey, to probe for buried sites or not to probe, are based on what he or she believes is the most likely occurrence. Make no mistake, though the decision may be based on subjective inferences not subject to testing, it is based on an intuitive model of how the archaeological record was formed and its current condition.

The ultimate goal of predictive modeling is not, as some may claim, to lower costs. The ultimate goal is to make the best decision about archaeological resources in the most efficient manner. We strongly believe that good decisions will put the right dollars on the right resources. It will save money because the current situation is highly inefficient. Managers initiate the compliance process for each project as though they and their archaeological contractors know nothing about the installation's archaeology after expending millions of dollars and nearly 50 years of effort. The truth is we do know something; in fact, we know quite a lot. The problem is presenting that information in a way that others can readily understand and that allows all parties to come to a reasonable solution. That is the promise of predictive modeling.

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# APPENDIX A

# POINTS OF CONTACT

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# APPENDIX B

# FIRST DRAFT OF SECTION 106 PROGRAMMATIC AGREEMENT FOR MANAGING ARCHAEOLOGICAL RESOURCES AT EGLIN AFB, FLORIDA

## FIRST DRAFT

## PROGRAMMATIC AGREEMENT AMONG EGLIN AIR FORCE BASE FLORIDA STATE HISTORIC PRESERVATION OFFICER AND ADVISORY COUNCIL ON HISTORIC PRESERVATION REGARDING MANAGEMENT OF ARCHAEOLOGICAL SITES AT EGLIN AIR FORCE BASE, FLORIDA

**WHEREAS**, Eglin Air Force Base (Eglin AFB) has under its jurisdiction approximately 464,000 acres encompassing portions of in Okaloosa, Santa Rosa, and Walton Counties, Florida (Appendix A); and

**WHEREAS**, Eglin AFB plays a vital role in the development and testing of weapons and tactics, a mission it has met in the defense of the nation from 1940 until the present day, and is headquarters to the Air Armament Center (AAC), a component of the Air Force Material Command (AFMC); and

**WHEREAS,** over the years Eglin AFB has evolved into an extensive training complex including the Eglin Main cantonment, three air fields (Eglin Main Field, Choctaw Field, and Duke Field), multiple bombing and firing ranges, closed training areas, drop zones, and shoreline infiltration areas, (Appendix B); and

**WHEREAS**, Eglin AFB, in consultation with the Advisory Council on Historic Preservation (ACHP) and the Florida State Historic Preservation Officer (SHPO), has determined that future undertakings, including but not limited to, construction and development, weapons testing, troop training, explosive ordinance disposal (EOD) clearance, forestry and prescribed burns, road maintenance, and landscaping may adversely affect historic properties (prehistoric and historic archaeological sites) listed in or eligible for listing in the National Register of Historic Places (NRHP) (here after “archaeological sites”); and

**WHEREAS**, Eglin AFB has further consulted with ACHP and SHPO regarding its responsibility to manage its archaeological sites in accordance with Sections 106 of the National Historic Preservation Act (NHPA) (16 U.S.C. §470f) and its implementing regulations at 36 CFR Part 800; and

**WHEREAS,** Eglin AFB is also responsible for identifying, evaluating, and nominating archaeological sites properties to the NRHP in accordance with Section 110 of the NHPA and is actively engaged in Section 110 cultural resources inventory of the base; and

**WHEREAS,** Eglin AFB, wishes to comprehensively meet its management responsibilities in a manner that balances its regulatory obligations with its need for operational flexibility and seeks, therefore, to enter into a Programmatic Agreement (PA) with the ACHP, SHPO, Native American tribes, and other consulting parties as provided under 36 CFR Part 800.14; and

**WHEREAS**, Eglin AFB has consulted with the Miccosukee Tribe of Indians of Florida, the Seminole Tribe of Florida, the Poarch Band of Creek Indians of Alabama, the Muscogee (Creek) Nation of Oklahoma, and the Thlopthlocco Tribal Town of the Creek (Muscogee) Nation (of Oklahoma) (hereafter the Tribes) regarding management of, and effects to, archaeological sites of religious and cultural significance to the Tribes and has invited them to be concurring parties to this PA; and

**WHEREAS**, Eglin AFB, has built a nationally recognized cultural resources management program and is committed to meeting its responsibilities to be a good steward of the nation’s heritage resources and to meet its regulatory obligations under federal law; and

**NOW THEREFORE,** Eglin AFB, SHPO, and ACHP agree that future management of Eglin AFB’s archaeological sites shall be administered in accordance with the following stipulations.

**Stipulations**

**I. Identification**

A. Archaeological Predictive Models

1. Eglin AFB has developed two installation-wide archaeological predictive models, referred to collectively as the “Site Probability Model,” which it uses for managing its archaeological sites in compliance with Sections 106 and 110 of the NHPA, as briefly described below.

    (a) The prehistoric site model, developed first in 1982 and adopted in 1993, correlates the location of prehistoric archaeological sites with key environmental variables (proximity to potable water, elevation above potable water sources, and proximity to the coast lines and alluvial planes). Eglin AFB uses these data to characterize the landscape within the base as either high or low probability for prehistoric archaeological sites.

    (b) The historic site model, added in 2001, identifies the expected location of historic homesteads and other settlements that are now archaeological sites by researching historic maps and archival records on homestead claims. Eglin AFB uses these data to characterize the landscape within the base as either high or low probability for historic archaeological sites.

2. In 2010–2011, Eglin AFB, in cooperation with the Department of Defense's Environmental Security Technology Certification Program (ESTCP), tested, refined, and validated the prehistoric site model. The ESTCP modeling project produced a refined surface model and a zonal management model. The zonal management model combines the surface model, a preliminary subsurface geo-archaeology model, and, a "red flag" model that predicts the location of certain classes of prehistoric archaeological sites (prehistoric villages, mounds). Both modeling products, the refined surface model and the zonal management model, will be part of the suite of modeling tools referred to here after as "the prehistoric site model."

3. Eglin AFB will continue to use the prehistoric site model and the historic site model to make planning and management decisions in compliance with Sections 106 and 110.

4. For a period of five years following the execution of this PA Eglin AFB will review, test, and upgrade, as needed, the prehistoric site model to ensure its continued accuracy and reliability. Once a year, during this five-year period, Eglin AFB will meet with SHPO and report on the review of the prehistoric site model.

5. To ensure that the prehistoric site model is reviewed, tested, and upgraded, as needed, in a manner that is acceptable to both Eglin AFB and SHPO, Eglin AFB, in consultation with SHPO, will hire an outside contractor to conduct the annual review and to make recommendations for any improvements to the prehistoric site model that may be needed. The contracting firm shall have demonstrated experience in building, testing/evaluating, and upgrading GIS statistically based archaeological predictive models.

6. Eglin AFB understands that modeling is an iterative process and that the prehistoric site model, as revised in 2011, will require continuous testing and refinement over time. For this reason Eglin AFB is committed to enhancing the accuracy and reliability of the prehistoric site model and will make any improvements it deems appropriate to achieve this end. These improvements may include, but are not limited to, conducting additional archaeological survey in low probability areas needed to statistically test and refine the prehistoric site model.

B. Identification Procedures

1. Eglin AFB will use the Site Probability Model to guide all archaeological surveys for Section 106 undertakings and Section 110 management projects in the following manner:

   (a) Areas identified as low probability areas for prehistoric and historic archaeological sites will not require archaeological survey, but may be surveyed to collect data needed to statistically test the prehistoric site model.

   (b) Areas identified as medium probability areas for prehistoric sites will require 50% survey, where surface conditions allow, unless otherwise exempted under

Stipulation VI.A. Survey standards will follow the standards used for archaeological survey in the High Probability Area (HPA).

(c) Areas identified as HPA for prehistoric, homestead/historic or wetlands will require 100% archaeological survey, where surface conditions allow, unless otherwise exempted under Stipulation VI.A. All archaeological survey conducted in the HPA will follow the survey standards for each HPA survey category set forth in the Eglin AFB Integrated Cultural Resources Management Plan (ICRMP) attached herein by reference.

2. All identification will be conducted by professional archaeologists who meet the qualification standards in Stipulation V.

## II. National Register Eligibility

A. At Eglin AFB, archaeological sites require subsurface testing to determine their NRHP eligibility status for Section 106 undertakings or Section 110 management projects. Any archaeological site that requires NRHP evaluation that has not been previously evaluated will be tested for NRHP eligibility in the following manner.

1. Eglin AFB will not be required to consult with SHPO prior to eligibility testing.

2. All testing of archaeological sites will be conducted by a professional who meets the qualification standards in Stipulation V.

3. If an archaeological site can be avoided in accordance with Stipulation III.B, Eglin AFB may choose not to test the site for NRHP eligibility until a later time. Under these circumstances, the undertaking may take place provided that any measures necessary to ensure avoidance are put in place.

B. Eglin AFB, in consultation with SHPO, will make a determination of NRHP eligibility for any archaeological site not previously evaluated that will be adversely affected by the undertaking. The Tribes will not be consulted about NRHP eligibility; however, Eglin AFB will provide the Tribes with NRHP information on all prehistoric sites evaluated in the previous year to be presented in an annual report as provided for in Stipulation XIV.B.

C. In those cases where Eglin AFB must make a determination of NRHP eligibility because an archaeological site may be adversely affected, or it chooses to make an NRHP eligibility determination following avoidance, Eglin AFB will follow the procedures presented below.

1. Eglin AFB shall submit an archaeological testing report to SHPO for a 30-day review along with its eligibility recommendations.

2. If the SHPO does not respond within the prescribed 30-day comment period, Eglin AFB will assume that SHPO has no objection to its eligibility determination.

3. Where there is agreement on eligibility between Eglin AFB and the SHPO, the eligibility determination will be accepted by both parties. Any disagreement between Eglin AFB and the SHPO over the eligibility determination shall be submitted by Eglin AFB to the Keeper of the National Register for determination pursuant to 36 CFR Part 63. The Keeper's determination shall be final.

## III. Effect and Avoidance of Effect

A. Eglin AFB will determine the effects of each undertaking on NRHP eligible archaeological sites in the following manner.

1. Eglin AFB will consult with the SHPO whenever an undertaking may have an adverse effect to archaeological sites, or Eglin AFB determines the undertaking may have an effect but the effect will not be adverse.

2. Eglin AFB will consult with the Tribes whenever an undertaking may have an adverse effect to prehistoric archaeological sites.

3. Eglin AFB will not be required to consult on effect with SHPO, the Tribes, or the other consulting parties in the following circumstances:

    (a) Where no cultural resources are found within the Area of Potential Effects (APE);

    (b) Where cultural resources are found but they have been determined not to be eligible through prior consultation with SHPO; or

    (c) Where NRHP eligible archaeological sites, previously determined to be eligible through consultation with SHPO, are found but will be avoided in accordance with Stipulation III.B.

4. Documentation supporting these "no effect" determinations will be provided to the SHPO and to the Tribes in an annual report as provided for in Stipulation XIV.A and XIV.B respectively.

B. Avoidance

1. All historic properties will be avoided whenever possible for the duration of this agreement. Where avoidance is not possible or desirable, Eglin AFB shall resolve the adverse effects of the undertaking in accordance with Stipulation IV.

2. Avoidance and preservation in place of archaeological sites will require use of highly visible avoidance measures installed on the ground around the recorded limits of the sites or buildings for the purpose of communicating "off limits" during the undertaking. The avoidance measures shall include one or more of the following as needed.

(a) Flagging: Installing temporary flagging around the limits of the site using colored flagging tape.

(b) Painting trees/vegetation: Applying highly visible paint to trees or other vegetation.

(c) Temporary fencing: Installing temporary fencing around the limits of the site using removable fencing, such as chain link fencing or wire and T posts.

(d) Other removable barriers: Installing removable barriers, such as earthen berms or portable concrete barriers.

(e) Signage: Installing permanent or semi-permanent signage at eye level in proximity to the site.

(f) Gating and other permanent barriers: Constructing permanent barriers, such as gates, around the limits of sites.

3. Eglin AFB will map the location of all archaeological sites to be avoided for the undertaking and describe in writing the avoidance measures used for each site.

4. Eglin AFB shall install all avoidance measures and ensure that for the undertaking all avoidance measures are in place on the ground before the undertaking commences. Eglin AFB will not be required to consult with the SHPO or other consulting parties when avoidance can be achieved, but may seek their advice, as needed.

5. If Eglin AFB determines, in consultation with SHPO, that avoidance is not possible, and there will be an adverse effect to an archaeological site, then Eglin AFB will mitigate the effects of the undertaking in accordance with a treatment plan.

C. Archaeological Monitoring

1. Eglin AFB may conduct archaeological monitoring as a means of ensuring avoidance, with or without the avoidance measures in Stipulation III.B; or, as a means of ensuring an undertaking will have no adverse effect to archaeological sites.

   (a) All archaeological monitoring will be conducted by an archaeologist that meets the professional qualifications standards in Stipulation V.

   (b) The archaeological monitor will be authorized to record features, collect artifacts and samples, take photographs, draw maps, and write notes, as needed. The monitor shall have the expressed authority to temporarily stop or redirect ground disturbing activities, as needed, at any time for the purposes of archaeological monitoring.

   (c) A report of the monitoring activities will be prepared and submitted to the SHPO.

2. Should undisturbed archaeological deposits be observed during monitoring, the monitor will halt ground disturbing activities and immediately report a possible discovery to the Eglin AFB. If Eglin AFB determines these deposits represent either an unknown archaeological site or an unrecorded portion of a known site, it will declare the deposits to be an unanticipated archaeological discovery. Eglin AFB shall then follow the provisions for unanticipated archaeological discovery in Stipulation VII.

**IV. Resolution of Adverse Effects**

A. If avoidance of archaeological sites is not possible or desirable, Eglin AFB shall resolve the adverse effects of the undertaking through archaeological data recovery or by means of alternative mitigation. All archaeological data recovery or alternative mitigation shall be conducted by a professional meeting the qualification standards in Stipulation V.

B. Archaeological Data Recovery

Eglin AFB will ensure that archaeological data recovery is conducted in the following manner.

1. A data recovery plan shall be prepared. At a minimum, the plan shall include:

    (a) A description of the proposed undertaking that will adversely affect archaeological sites

    (b) A description of each archaeological site and how each may be affected by the proposed undertaking

    (c) A set of research questions and objectives

    (d) A description of methods to be used in collecting the data needed to address the research questions

    (e) A description of analytical techniques to be used in addressing the research questions

    (f) A description of the nature of materials and features expected to be revealed, materials expected to be collected, and all other materials to be generated including reports and associated media

2. Eglin AFB shall submit the data recovery plan to SHPO for 45-day review. If the archaeological site is prehistoric in age, Eglin AFB shall also submit the data recovery plan to the Tribes for 45-day review. The tribal review period will run concurrently with the SHPO review.

    (a) If the SHPO or one or more of the Tribes does not respond within the prescribed review period, Eglin AFB shall assume that party has no objection to the proposed

treatment. Eglin AFB, in completing the data recovery plan, will take into account any comments it does receive from the SHPO or the Tribes within the prescribed review periods.

(b) Once Eglin AFB has completed the data recovery plan, it shall ensure that the data recovery is conducted in accordance with the plan.

(c) All archaeological data recovery shall be reported within 12 months of the end of field work. Eglin AFB shall ensure that a draft of the report is prepared and will submit the draft to SHPO and the Tribes for a 45-day review. Any comments received by Eglin AFB from SHPO or any of the Tribes, within the prescribed review period shall be considered in completing the report. Eglin AFB shall provide the SHPO and the Tribes with one copy of any final report.

3. Eglin AFB may prepare historic context studies to guide archaeological data recovery and the preparation of archaeological data recovery plans. These historic contexts may be base-wide in scope, focus on a particular archaeological site type or time period, apply to a subarea of the Eglin AFB reservation, or be developed for a particular undertaking. Historic context studies shall be prepared in consultation with the consulting parties.

C. Alternative Mitigation

If Eglin AFB determines that resolution of adverse effects can best be achieved through means other than archaeological data recovery, it may adopt an alternative mitigation strategy on a case-by-case basis as presented below.

1. If the alternative mitigation will apply to historic archaeological sites, Eglin AFB will submit a mitigation plan to the SHPO for 45-day review. Eglin AFB shall take into consideration any comments it receives from the SHPO during the 45-day review period. If the SHPO does not respond within the 45-day review period, Eglin AFB shall assume the SHPO has no objection to the alternative mitigation.

2. If the alternative mitigation will apply to prehistoric archaeological sites, or historic archaeological sites with a prehistoric component, Eglin AFB will submit a mitigation plan to the SHPO and Tribes for a 45-day review. The tribal review period will run concurrently with SHPO review. Eglin AFB shall take into consideration any comments it receives from the SHPO or any one of the Tribes during the prescribed review period. If the SHPO, or one or more of the Tribes, do not respond within the prescribed review period, Eglin AFB shall assume that party has no objection to the alternative mitigation.

3. All alternative mitigation shall be reported within 12 months of the end of field work. Eglin AFB shall ensure that a draft of the report is prepared and will submit the draft to SHPO and to the Tribes, as applicable, for a 45-day review. Any comments received by Eglin AFB from SHPO or any of the Tribes, as applicable, within the prescribed review

period shall be considered in completing the report. Eglin AFB shall provide the SHPO and the Tribes each with one copy of any final report.

D. Standards

Eglin AFB will ensure that resolution of adverse effects to all archaeological sites through data recovery or alternative mitigation is conducted in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation.

## V. Qualifications

All investigation of archaeological sites conducted under the terms of this PA, including but not limited to, field work, archival research, artifact curation, and report preparation; and, all management of archaeological sites including, but not limited to, identification, evaluation of NRHP eligibility, assessment of effect, and treatment of effect, as the case may be, shall be conducted by, or under the supervision of, a person who meets the Secretary of the Interior's Standards and Guidelines for professional qualifications in archaeology described in the Federal Register: June 20, 1997 (Volume 62, Number 119, pages 33707-33723).

## VI. Exemptions

A. The following areas shown on the map attached in Appendix C shall be exempted from the terms of this PA. These areas contain hazardous materials and are too dangerous to access for cultural resources investigations; or, they are off limits for reasons of national security. If, in the future, Eglin AFB determines that the exempted areas are accessible because the hazards preventing safe access have been removed or neutralized; or, the security restrictions have been lifted, then Eglin AFB will consult with the parties to this PA, in accordance with Stipulation XII, and amend the map in Appendix C. Thereafter, any area or areas removed from the map in Appendix C, will be subject to the terms of this PA.

B. The following undertakings, listed in Appendix D, shall be exempted from the terms of this PA. These undertakings are determined to have little or no potential to affect National Register-eligible historic properties. If, in the future, Eglin AFB determines that the list of exempted undertaking should be added to or subtracted from, then Eglin AFB will consult with the parties to this PA, in accordance with Stipulation XII, and amend the list in Appendix D. Thereafter, any undertaking not listed as exempt will be will be subject to the terms of this PA.

C. If during implementation or construction of any of these exempted undertakings, an unanticipated discovery is made, Eglin AFB shall follow the provisions for unanticipated discoveries in Stipulation VII below.

## VII. Unanticipated Discoveries

A. If a previously unknown archaeological site is discovered during an undertaking, or an unanticipated effect to a known archaeological site is discovered during an undertaking, Eglin AFB shall immediately take the following steps.

1. All ground disturbances in the vicinity of the discovery shall cease and the discovery location will be secured from further harm until the discovery is resolved.

2. A professional, meeting the qualification standards of Stipulation V shall record the discovery evaluating its nature, extent, condition, and NRHP eligibility and prepare a field report.

3. The field report will be prepared within 48 hours and be submitted to the Eglin AFB Cultural Resources Manager.

B. Eglin AFB shall consult with SHPO on the NRHP eligibility of the discovery and the potential effect of continued development within two working days of the discovery. If the discovery is a prehistoric archaeological site, Eglin AFB will also consult with the Tribes concurrently with the SHPO.

C. If, in consultation with SHPO, and, when applicable, the Tribes, Eglin AFB determines that the discovery is NRHP eligible and that treatment is warranted, Eglin AFB shall conduct treatment following the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation.

## VIII. Human Burials

A. If human remains and associated funerary objects are discovered during an undertaking, Eglin AFB shall immediately take the following steps.

1. All ground disturbing activity in the vicinity of the discovery shall cease and the discovery location will be secured from further harm until the discovery is resolved.

2. A professional, meeting the qualification standards of Stipulation V shall record the discovery evaluating its nature, extent, and condition and prepare a field report.

3. The field report will be prepared within 48 hours and submitted to the Eglin AFB Cultural Resources Manager.

4. Eglin AFB shall notify the Tribes within 48 hours of the discovery and provide a copy of the field report as soon as it is available. Eglin AFB may conduct analysis of the human remains, as needed, to determine their age and identity. Noninvasive techniques will be used whenever possible and if the remains need to be moved Eglin AFB will use natural fibers and materials (no plastic or synthetics) for this purpose.

B. If Eglin AFB determines the human remains are Native American; or, based on the preponderance of evidence, are likely to be Native American, it shall consult with the Tribes within 24 hours of its determination and comply with 43 CFR Part 10, the regulations implementing the Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001 et seq.).

C. If Eglin AFB determines the human remains are not Native American, or, based on the preponderance of evidence, are not likely to be Native American, Eglin AFB will consult with SHPO pursuant to 36 CFR Part 800 to resolve the discovery. Subsequently, should the remains be identified as Native American, Eglin AFB will consult with the Tribes pursuant to NAGPRA.

D. If Eglin AFB cannot determine the origin of the human remains as either Native American or non-Native American, it shall treat the remains as Native American and accordingly consult with the Tribes pursuant to NAGPRA.

## IX. Declared Emergencies

A. Natural disasters such as hurricanes, tornados, tidal surges, etc. may occur requiring an immediate response by Eglin AFB in order to protect health, safety, and property. In the event of an emergency declared by the President of the United States or the Governor of the State of Florida, pursuant to 36 CFR Part 800.12, the following emergency actions, which could otherwise by undertakings, are exempted from further consideration under this PA.

1. Protection of the human health and/or the environment from damage or harm by hydrocarbon or hazardous waste

2. Prevention of imminent damage resulting from the threat of hurricane, tornado or other natural disasters

3. Stabilization necessitated by the threat of imminent structural failure (e.g. repair of replacement of building footings)

4. Actions waived from the usual procedures of Section 106 compliance, pursuant to 36 CFR 800.12 (d)

B. Once the President of the United States or the Governor of the State of Florida declares the emergency to be over, Eglin AFB will conduct an inspection of all archaeological sites located in the areas of the base where Eglin AFB has reason to believe the integrity of the sites may have been compromised during the emergency. Eglin AFB will record the condition of the archaeological sites, evaluate their NRHP eligibility status, and recommend any actions needed to protect, stabilize, and preserve the properties. This report will be sent to SHPO for review and comment.

C. Should Eglin AFB propose follow-up stabilization or other protective measures, including salvage excavation, to any archaeological site at the conclusion of the emergency, and those

measures may result in additional effects, Eglin AFB shall consult with SHPO to develop a treatment strategy for those sites.

D. In all those cases in which Eglin AFB concludes that damage to archaeological sites resulting from the emergency is so severe that their integrity has been compromised, then, with SHPO concurrence, Eglin AFB may determine that these properties are no longer NRHP eligible.

**X. Failure to Comply**

A. If and when Eglin AFB is responsible for authorizing an action that would otherwise have been reviewed as an undertaking in accordance with this PA prior to such authorization, Eglin AFB shall, upon learning of the incident, immediately investigate the incident.

B. Eglin AFB will ensure that a professional meeting the qualification standards in Stipulation V inspects the location and prepares a damage assessment report within 30 days. The report will, at a minimum, include:

1. A description of the incident;

2. A description of any historic properties that may have been affected by the incident;

3. A description of the effects of the incident on archaeological sites, if any; and

4. A description of the steps that will be taken to protect, stabilize, and preserve any affected archaeological sites.

C. Eglin AFB will send the damage assessment report to the SHPO and to appropriate agencies, departments and clients within the base along with an explanation of what steps Eglin AFB will take to ensure that similar failures to comply will not happen again in the future.

**XI. Dispute Resolution**

A. Should any signatory or consulting party object to any actions proposed or the manner in which the terms of this PA are implemented, Eglin AFB shall consult with such party to resolve the objection. If Eglin AFB determines that the objection cannot be resolved, Eglin AFB will forward all documentation relevant to the objection, including a proposed response, to ACHP.

B. Within forty-five (45) days after receipt of all pertinent documentation, ACHP shall exercise one of the following options:

1. Advise Eglin AFB that ACHP concurs with Eglin AFB's proposed response to the objection, whereupon Eglin AFB will respond to the objection accordingly; or

2. Provide Eglin AFB with recommendations, which Eglin AFB shall take into account in reaching a final decision regarding its response to the objection; or

3. Notify Eglin AFB that the objection will be referred for comment pursuant to 36 CFR §800.7(a)(4), and proceed to refer the objection and comment; Eglin AFB shall take the resulting comment into account in accordance with 36 CFR §800.7(c)(4).

C. Should the ACHP not exercise one of the above options within forty-five (45) days after the receipt of all pertinent documentation, Eglin AFB may assume the ACHP's concurrence with its proposed response to the objection.

D. Eglin AFB shall take into account any ACHP comment or recommendation provided in accordance with this stipulation with reference only to the subject of the objection; its responsibility to carry out all actions under this agreement that are not the subject of the objection shall remain unchanged.

## XII. Amendments

Any signatory to this PA may propose to the other signatory that it be amended, whereupon the signatories will consult in accordance with 36 CFR § 800.6(c)(7) to consider such an amendment. If the signatories cannot agree to appropriate terms to amend the PA, the PA may be terminated in accordance with Stipulation XIII below.

## XIII. Termination

Any signatory to this agreement may revoke it upon written notification to the other parties by providing thirty (30) days notice to the other parties, provided that the parties will consult during the period prior to termination to seek agreement on amendments or other actions that would avoid termination. In the event of termination, Eglin AFB shall comply with 36 CFR §800 with regard to individual undertakings covered by this PA.

## XIV. Annual Report

A. Every year, within 30 days of the anniversary of the signing of this agreement, Eglin AFB shall submit a report to the SHPO regarding determinations of effect made in the previous year in which prior SHPO consultation is not required under Stipulation III.A.4.

B. Every year, within 30 days of the anniversary of the signing of this agreement, Eglin AFB shall submit a report to the Tribes regarding determinations of NRHP eligibility and effect made in the previous year in which consultation with the Tribes is not required under Stipulations II.B and III.A.4.

C. These annual reports may be produced as a single report and sent to both the SHPO and the Tribes.

## XV. Triennial Review

Every three years, Eglin AFB shall meet with the SHPO and the other consulting parties to review the performance of this agreement and determine if amendments are needed to improve its effectiveness.

## XVI. Sunset Provisions

This PA shall become effective on the date it is signed by the ACHP and shall remain in effect for a period of 12 years, unless extended by unanimous approval of the signatories or terminated in accordance with Stipulation XIII.

## Execution

Execution and implementation of this PA is evidence that Eglin AFB has satisfied its Section 106 responsibilities in managing its archaeological sites.

**Signatories:**
Advisory Council on Historic Preservation
Eglin Air Force Base
Florida State Historic Preservation Officer

**Concurring Parties:**
Miccosukee Tribe of Indians of Florida
The Seminole Tribe of Florida
Poarch Band of Creek Indians
Muscogee (Creek) Nation
The Thlopthlocco Tribal Town of the Creek (Muscogee) Tribe

**Appendices:**
Appendix A: Vicinity map of Eglin AFB [not included]
Appendix B: Map of Eglin AFB Reservation [not included]
Appendix C: Map of areas exempted from the identification requirements [not included]
Appendix D: List of undertakings exempted from the identification requirements [not included]

# APPENDIX C:

# FIRST DRAFT OF SECTION 106 PROGRAMATIC AGREEMENT FOR MANAGING CULTURAL RESORUCES AT FORT DRUM, NEW YORK

**<u>FIRST DRAFT</u>**

**PROGRAMMATIC AGREEMENT**
**AMONG**
**UNITED STATES ARMY, FORT DUM**
**NEW YORK STATE HISTORIC PRESERVATION OFFICER**
**AND**
**ADVISORY COUNCIL ON HISTORIC PRESERVATION**
**REGARDING**
**MANAGEMENT OF HISTORIC PROPERTIES AT FORT DRUM, NEW YORK**

**Whereas,** for over 100 years Fort Drum, and its predecessors, has been an important part of the United States Army (U.S. Army) training mission and currently is home to the 10$^{th}$ Mountain Division, Light Infantry, one of the most active military units in the U.S. Army; and

**Whereas,** Fort Drum has under its jurisdiction approximately 107,265 acres encompassing portions of Jefferson and Lewis Counties, New York (Appendix A); and

**WHEREAS,** to meet its training mission Fort Drum uses approximately 30,000 acres as firing ranges and impact areas, over 11,000 acres make up the Cantonment, including the Wheeler-Sack Army Airfield, and 66,000 acres are devoted to troop maneuvers and other training activities (Appendix B); and

**WHEREAS**, Fort Drum, in consultation with the Advisory Council on Historic Preservation (ACHP) and the New York State Historic Preservation Office (SHPO), has determined that future training may adversely affect historic properties that are listed in or eligible for listing in the National Register of Historic Places (NRHP); and

**WHEREAS,** these historic properties include multiple previously recorded prehistoric and historic archaeological sites, five archaeological NRHP listed historic districts, the LeRay Mansion Historic District, 13 historic cemeteries, and two properties of religious and cultural significance to federally recognized Indian tribes; and

**WHEREAS**, Fort Drum has further consulted with ACHP and SHPO regarding its responsibility to manage its historic properties in accordance with Sections 106 of the National Historic Preservation Act (NHPA) (16 U.S.C. §470f) and its implementing regulations at 36 CFR Part 800; and

**WHEREAS,** Fort Drum is also responsible for identifying, evaluating, and nominating historic properties to the NRHP in accordance with Section 110 of the NHPA and is actively engaged in Section 110 cultural resources inventory of the base; and

**WHEREAS,** Fort Drum, wishes to comprehensively meet its management responsibilities in a manner that balances its regulatory obligations with its need for operational flexibility and seeks, therefore, to enter into a Programmatic Agreement (PA) with the ACHP, SHPO, Native American tribes and other consulting parties as provided under 36 CFR Part 800.14; and

**WHEREAS,** Fort Drum has invited the ACHP to participate in consultations concerning management of historic properties at Fort Drum and the ACHP has agreed to participate in such consultations; and

**WHEREAS**, Fort Drum has consulted with the Oneida Indian Nation, the Onondaga Nation, and the St. Regis Mohawk Tribe (hereafter the tribes) regarding management of, and effects to, historic properties of religious and cultural significance to the tribes and has invited them to be concurring parties to this PA; and

**WHEREAS**, Fort Drum, since 1985 has built a nationally recognized cultural resources management program and is committed to meeting its responsibilities to be a good steward of the nation's heritage resources and to meet its regulatory obligations.

**NOW THEREFORE,** Fort Drum, SHPO, and ACHP agree that future management of Fort Drum's historic properties shall be administered in accordance with the following stipulations.

**Stipulations**

## I. Background

A. Fort Drum encompasses 107,265 acres in upstate New York. It is utilized primarily for military training and is the permanent home of the 10$^{th}$ Mountain Infantry Division (Light). Within the Fort Drum reservation the Cultural Resources Manager (CRM), under the Environmental Division, Public Works, is responsible for managing historic archaeological sites, prehistoric archaeological sites and historic buildings and structures in compliance with Sections 106 and 110 of the NHPA and all applicable Department of Defense (DoD) directives and Department of the Army instructions.

B. Between 1984 and 1988, Louis Berger and Associates (LBA) conducted a cultural resources inventory of 11,189 acres, during which approximately 400 archaeological sites were identified, primarily from the historic period. Six historic contexts were drafted by LBA, as further described below. In 1989, the cultural resources program was established at Fort Drum and in that year its cultural resources inventory program was initiated to identify prehistoric sites on the Fort. Approximately 90% of Fort Drum has been inventoried or cleared for prehistoric archaeological sites since then. In 2008, the Army Corps of Engineers reviewed the building stock at Fort Drum to further identify historic properties related to World War II and the Cold War era.

C. Today, Fort Drum manages nearly one thousand archaeological sites from the historic and prehistoric time periods representing the last 10,000 years, and hundreds of historic buildings and structures dating from the 18$^{th}$ through the middle 20$^{th}$ centuries, including the

Le Ray Mansion Historic District and 13 historic-period cemeteries. In the near future, additional historic buildings and structures will become potentially eligible for listing to the NRHP and will require evaluation. This PA contains procedures that allow Fort Drum to meet its statutory obligations to be a good steward of the nation's historic properties while providing for the operational flexibility it needs to meet its mission in support of the nation's defense.

## II. Procedures for Managing Historic Archaeological Sites

A. Inventory of historic archaeological sites has been completed at Fort Drum. Five historic contexts developed by LBA provide management guidance for historic archaeological sites. In 1987, Fort Drum entered into a Memorandum of Agreement (MOA) with the SHPO that accepts documentation as sufficient for mitigating future effects to certain types of historic archaeological sites as indicated below.

1. ***The Farmstead Historic Context, circa 1800–1920***. Involves foundations and archeological remains of Fort Drum farmsteads—the foci of family residence and farm production for a majority of the region's residents during this period. This context is considered as mitigated by the MOA between Fort Drum and the SHPO.

2. ***The Dispersed Agricultural Processing Industries Historic Context, circa 1800–1920***. Involves foundations and archeological components of sites related to industries intended to process agricultural and natural resource products, outside of nucleated village settlements on the Fort Drum lands. At present, this context is not considered as mitigated, or governed by the MOA between Fort Drum and the SHPO.

3. ***The Rural Village Historic Context, circa 1800–1920.*** Covers foundations and archeological components of small rural villages, often associated with an iron furnace or mill complex (especially a gristmill or gristmill complex), found within the boundaries of Fort Drum. This context is considered as mitigated by the MOA between Fort Drum and the SHPO.

4. ***Dispersed Social Centers Historic Context, circa 1800–1920.*** Consists of foundations and archeological remains from centers of non-farm and extra-family social activity located in completely rural areas (outside the recognized boundaries of villages) and created to facilitate and express the social lives of area residents. At present, this context is not considered as mitigated, or governed by the MOA between Fort Drum and the SHPO.

5. ***The Iron Industry Historic Context*** *(see LBA 1994:Technical Appendix 2, Task Order 15, Section 3),* ***circa 1830–1885***. This covers the archaeological remains of three blast furnaces (Lewisburg/Sterlingbush, Sterlingville, and Alpina) constructed in the region during the 1830s to exploit local deposits of iron ore and operated sporadically until the early 1880s. Also covered are ancillary structures and facilities, e.g., the lime kilns that supplied lime flux to Sterlingbush and possibly Alpina Furnaces. Iron furnace sites

(with the exception of Alpina) are associated with rural villages. This context is considered as mitigated by the MOA between fort drum and the SHPO.

B. No additional archaeological investigation is required for historic archaeological resources that are covered by historic contexts 1, 3, and 5 as provided for in the MOA between Fort Drum and the SHPO. Additional investigation of historic archaeological properties covered by historic contexts 2 and 4 may be conducted in the future to achieve mitigation; this will require consultation between Fort Drum and SHPO. Until that time, Fort drum will follow the same procedures in Stipulations III.C through III.E whenever historic archaeological sites covered by historic contexts 2 and 4 may be effected by an undertaking.

C. Any undertaking that may affect the 13 historic cemeteries that Fort Drum manages will require consultation with the SHPO outside of the terms of this PA in compliance with 36 CFR §800.

D. Any previously unknown historic archaeological sites discovered during an undertaking anywhere on Fort Drum, will be an unanticipated discovery. Fort Drum shall resolve the unanticipated discovery following Stipulation VII.

## III. Procedures for Managing Prehistoric Archaeological Sites

A. Archaeological Predictive Models

1. Fort Drum has developed four predictive models that it uses for managing prehistoric archaeological sites in compliance with Sections 106 and 110 of the NHPA, as briefly described below.

    a. Glacial Landscape model correlates the location of prehistoric archaeological sites with key environmental variables (proximity to ravines/fossil waterways, elevation and soils) in two post glacial physiographic zones that make up the majority of the base: The Ontario-St. Lawrence Lowlands and the Pine Plains Sands.

    b. Adirondack Uplands model deduces where prehistoric archaeological sites should be expected in the foothills of the Adirondack Mountains, which includes the upland areas of the base.

    c. Paleo-Maritime model extrapolates the ancient shore lines of glacial Lake Iroquois and predicts where shore line settlement ought to be located within the base.

    d. Prehistoric-Pathways model predicts where sites associate with prehistoric trail systems that pass through Fort Drum can be expected.

2. In 2010, Fort Drum, in cooperation with the DoD’s Environmental Security Technology Certification Program, refined and validated the Glacial Landscape and Upland models creating a single base-wide archaeological predictive model (here after “revised predictive model).

3. Fort Drum will use the revised predictive model to meet its identification responsibilities under Sections 106 and 110 as further described in Stipulation III B. The SHPO accepts the use of the revised predictive model for this purpose.

4. For a period of five years following the execution of this PA, Fort Drum will review, test, and upgrade, as needed, the revised predictive model to ensure its accuracy and reliability. Once a year, during this five-year period, Fort Drum will meet with SHPO and report on the review of the revised predictive model. This requirement may be met during the annual review meeting between Fort Drum and the SHPO required under Stipulation XIII.

5. To ensure that the revised predictive model is reviewed, tested, and upgraded, as needed, in a manner that is acceptable to both Fort Drum and SHPO, Fort Drum, in consultation with SHPO, will hire an outside contractor to conduct the annual review and to make recommendations for any improvements to the revised predictive model that may be needed. The contracting firm shall have demonstrated experience in building, testing/evaluating, and upgrading GIS statistically based archaeological predictive models.

6. Fort Drum understands that modeling is an iterative process and that the revised predictive model will require continuous testing and refinement over time. For this reason, Fort Drum is committed to enhancing the accuracy and reliability of the revised predictive model and will make any improvements it deems appropriate to achieve this end. These improvements may include, but are not limited to, conducting additional archaeological survey, including re-survey of previously surveyed areas and random survey of the low sensitivity areas, that may be needed to further test and refine the revised predictive model.

7. Fort Drum has shared with SHPO its GIS data on archaeological sites and survey. Every two years, Fort Drum will provide an update of the archaeological database to SHPO.

B. Identification of Archaeological Sites

1. Ft Drum will apply the revised predictive model, and, as needed, the Paleo-Maritime and Prehistoric Pathways models, for all Section 106 undertakings and all Section 110 management projects, in the following manner:

    a. Areas identified as having low sensitivity for prehistoric archaeological sites will not require archaeological survey but may be surveyed to test the revised predictive model or for other purposes at the discretion of Fort Drum.

    b. Areas identified as medium sensitivity for prehistoric archaeological sites will require 50% survey, where surface conditions allow, unless otherwise exempted under Stipulation VI.A.

c. Areas identified as high sensitivity areas for prehistoric archaeological sites, including any area within 50 m of a navigable stream or river, will require 100% survey, where surface conditions allow, unless otherwise exempted under Stipulation VI.A.

2. All archaeological survey will be conducted in accordance with survey standards and procedures contained in the most current version of Fort Drum's Integrated Cultural Resources Management Plan (ICRMP) attached herein by reference. All archaeological surveys will be conducted by, or under the supervision of, an archaeologist who meets the professional qualifications standard in Stipulation V.

3. Fort Drum, in consultation with SHPO, shall establish and use standardized archaeological site definitions for all archaeological investigations at Fort Drum conducted pursuant to the terms of this PA. The definitions will be prepared by Fort Drum, in consultation with SHPO, within six (6) months of the execution of this PA and once completed will be attached to this PA as Appendix C.

4. All areas within the base Cantonment shall be subject to archaeological survey whenever undertakings are proposed within these limits, unless specifically exempted under Stipulation VI.B; or, unless the CRM at Fort Drum determines that previous ground disturbance has significantly reduced the probability of intact archaeological deposits. Should intact archaeological deposits be encountered during construction anywhere within the Cantonment, Fort Drum will follow the provisions for unanticipated discoveries in Stipulation VII.

C. Evaluation of Archaeological Sites

1. Fort Drum will apply the criteria for listing to the NRHP contained in 36 CFR part 60.4 to all archaeological sites recorded through identification for each Section 106 undertaking or Section 110 inventory.

2. Fort Drum will not consult with SHPO on NRHP eligibility for archaeological sites, unless Fort Drum requests such consultation.

3. A summary of all NRHP eligibility determinations Fort Drum makes each year will be submitted to SHPO in an annual management summary prepared pursuant to Stipulation XIV. Fort Drum will also provide SHPO all records on NRHP eligibility determinations upon request at any time.

4. Any dispute regarding NRHP eligibility, if not resolved through consultation between Fort Drum and SHPO, will be resolved by the Keeper of the National Register in accordance with 36 CFR Part 800.4 (c) (2).

D. Assessment of Effects to Archaeological Sites

1. Fort Drum will assess the effects of all Section 106 undertakings by applying the criteria of adverse effect in accordance with 36 CFR Part 800. 5.

2. Fort Drum will not consult with SHPO when an undertaking will have no effect to NRHP-eligible archaeological sites ("no historic properties affected"), unless Fort Drum requests such consultations. Circumstances under which no historic properties will be affected are as follows:

    a. When archaeological surveys do not identify prehistoric or historic archaeological sites; or

    b. When prehistoric or historic archaeological sites are located but determined by Fort Drum not to be eligible for listing to the NRHP; or

    c. When NRHP-eligible prehistoric or historic archaeological sites are found but are avoided through project design and preserved in place.

3. Fort Drum will not consult with SHPO when an undertaking may affect NRHP-eligible archaeological sites but the effect will not alter the characteristics that make the sites NRHP eligible by diminishing their integrity ("no adverse effect"), unless Fort Drum requests such consultation.

4. A summary of all "no historic properties affected" and "no adverse effect" determinations Fort Drum makes each year will be submitted to SHPO in an annual management summary prepared pursuant to Stipulation XIV. Fort Drum will also provide SHPO all records on these determinations at any time upon request.

5. Fort Drum will consult with the SHPO, the tribes, and the other consulting parties, whenever an undertaking may adversely affect NRHP-eligible archaeological sites. Unless the tribes indicate otherwise, however, Fort Drum will not consult with the tribes regarding adverse effects to historic archaeological sites.

6. Any dispute about effect determinations will be resolved following the provisions for dispute resolution in Stipulations X.

E. Resolution of Adverse Effects to Archaeological Sites

1. Avoidance

    a. All NRHP-eligible archaeological sites will be avoided whenever possible. Avoidance and preservation in place of NRHP eligible archaeological sites will require use of highly visible avoidance measures installed on the ground around the recorded limits of the sites or buildings for the purpose of communicating "off

limits" during the undertaking. The avoidance measures shall include one or more of the following as needed.

(i) Flagging: Installing temporary flagging around the limits of the site or building using colored flagging tape.

(ii) Temporary fencing: Installing temporary fencing around the limits of the site or building using removable fencing, such as chain link fencing or wire and T posts.

(iii) Other removable barriers: Installing removable barriers, such as earthen berms or portable concrete barriers.

(iv) Signage: Installing permanent or semi-permanent signage at eye level in proximity to the site. Fort Drum shall employ a universally recognizable symbol printed on metal or other durable material that is mounted on metal stakes or posts and set on the ground around the limits of the site.

(v) Gating and other permanent barriers: Constructing permanent barriers, such as gates, around the limits of sites.

b. Fort Drum will map the location of all archaeological sites to be avoided for the undertaking and describe in writing the avoidance measures used for each site.

c. Fort Drum shall install all avoidance measures and ensure that for the undertaking all avoidance measures are in place on the ground before the undertaking commences. Fort Drum will not consult with the SHPO or other consulting parties when avoidance can be achieved, but may seek their advice, as needed.

d. If Fort Drum determines that avoidance is not possible, and there may be an adverse effect to a historic property, then Fort Drum will resolve the adverse effects of the undertaking in accordance with a data recovery plan prepared in accordance with Stipulation III.E.3.

2. Archaeological Monitoring

a. Fort Drum may employ archaeological monitoring as a means of ensuring avoidance, with or without the avoidance measures in Stipulation III.E.1; or, as a means of ensuring an undertaking will have no adverse effect to a historic property.

(i) All archaeological monitoring will be conducted by an archaeologist that meets the professional qualifications standards in Stipulation V.

(ii) The archaeological monitor will be authorized to record features, collect artifacts and samples, take photographs, draw maps, and write notes, as needed. The monitor shall have the expressed authority to temporarily stop or

redirect ground disturbing activities, as needed, at any time for the purposes of archaeological monitoring.

(iii) A summary of all archaeological monitoring activities carried out during the previous year will be included in the annual management summary submitted to SHPO pursuant to Stipulation XIV.

b. Should intact archaeological deposits be observed during archaeological monitoring, and should the monitor determine these deposits represent either an unknown archaeological site or an unrecorded portion of a known site, the monitor will halt the undertaking and report the discovery to the CRM. If the CRM determines the deposits are an unanticipated discovery, Fort Drum shall follow the provisions for unanticipated discoveries in Stipulation VII.

3. Archaeological Data Recovery

a. Whenever NRHP-eligible archaeological sites cannot be avoided and may be adversely affected, Fort Drum will prepare a draft archaeological testing and/or data recovery plan and submit the draft plan to the SHPO and the other consulting parties for 30-day review.

b. If SHPO, or one or more of the other consulting parties, does not respond within 30 days of submittal, Fort Drum shall assume that party has no objection to the proposed testing and/or data recovery. If the SHPO, or one or more of the other consulting parties, objects to the testing and/or data recovery plans, however, Fort Drum will resolve the objection pursuant to Stipulation X. Fort Drum will take into account any comments or recommendations received from SHPO, or any of the other consulting parties, within the review period in preparing the final testing and/or data recovery plans.

c. Following the completion of field work for archaeological testing and/or data recovery, upon approval of the CRM, Fort Drum may initiate the undertaking provided that any analysis, report preparation, curation, or other tasks required in the testing and/or data recovery plan is completed in full within 12 months of the end of field work. Fort Drum shall prepare a draft of the report and submit the draft to SHPO, the tribes and the other consulting parties for 30-day review. Any comments received from SHPO, the tribes or any of the other consulting parties within the review period shall be considered by Fort Drum in making any revisions needed to complete the report.

d. Fort Drum will provide a copy of all reports to the consulting parties upon completion of all archaeological testing and data recovery

e. All archaeological testing and/or data recovery will be conducted by, or under the supervision of, a professional archaeologist meeting the qualification standards in

Stipulation V in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation, as amended and annotated.

f. Any dispute about resolution of adverse effect will be resolved following the provisions for dispute resolution in Stipulations X.

## IV. Procedures for Managing Historic Buildings and Structures

A. Existing Historic Buildings and Historic Districts

1. The LeRay Mansion Historic District is listed on the National Register. It consists of the second mansion built by James LeRay de Chaumont on the site in 1826–1827, four additional outbuildings, and the associated landscaping. The interiors of the four outbuildings have lost their integrity and were determined ineligible during the National Register listing of the District in the mid-1980s. A map of the LeRay Mansion Historic District and list of contributing and noncontributing properties are found in Appendix D.

2. Assessment of Effect

   a. Fort Drum will assess the effects of all Section 106 undertakings by applying the criteria of adverse effect in accordance with 36 CFR Part 800. 5.

   b. Fort Drum will not be required to consult with SHPO when an undertaking will have no effect on a historic property ('no historic property affected) or will affect a historic property but the effect will not alter the characteristics that make the property eligible by diminishing its integrity ("no adverse effect"), unless Fort Drum requests such consultation.

   c. A summary of all "no historic properties affected" and "no adverse effect" determinations Fort Drum makes each year will be submitted to SHPO in an annual management summary prepared pursuant to Stipulation XIV. Fort Drum will also provide SHPO all records on these determinations at any time upon request.

   d. Any dispute about effect determinations will be resolved following the provisions for dispute resolution in Stipulations X.

3. Resolution of Adverse Effects

   a. Fort Drum will consult with the SHPO and the other consulting parties whenever an undertaking will adversely affect the LeRay Mansion Historic District or any of its contributing properties.

   b. Fort Drum will submit a proposed treatment plan resolving the adverse effects to the SHPO and the other consulting parties for 30-day review.

c. If SHPO, or one or more of the other consulting parties, does not respond within 30 days of submittal, Fort Drum shall assume that party has no objection to the proposed treatment plan. Fort Drum will take into account any comments or recommendations received from SHPO, or any of the other consulting parties, within the review period in preparing the final treatment plan.

d. All resolution of adverse effects to NRHP eligible or listed historic buildings and structures will be conducted by, or under the supervision of, a professional architect or architectural historian meeting the qualification standards in Stipulation V in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings.

e. Any dispute about resolution of adverse effect will be resolved following the provisions for dispute resolution in Stipulations X.

B. Potential Historic Buildings

1. Identification and National Register Eligibility

a. There are 89 buildings listed in Appendix E that are 50 years of age or will turn 50 years of age by 2022.

b. Fort Drum will conduct an architectural survey within two years of the signing of this PA to document these 89 buildings and evaluate their NRHP eligibility.

c. Fort Drum, in consultation with the SHPO, will determine the NRHP eligibility of the 89 historic buildings.

d. Any dispute regarding NRHP eligibility, if not resolved through consultation between Fort Drum and SHPO, will be resolved by the Keeper of the National Register in accordance with 36 CFR Part 800.4 (c) (2).

2. Assessment of Effect

Fort Drum will follow the provisions of Stipulation IV.A.2 whenever a proposed undertaking may affect any historic building listed in Appendix E that is determined to be NRHP eligible.

3. Resolution of Adverse Effects

Fort Drum will follow Stipulation IV.A.3 whenever a proposed undertaking may adversely affect any historic building listed in Appendix E that is determined to be NRHP eligible.

C. Program Alternatives

1. World War II Temporary Building Programmatic Agreement

   There are 305 buildings listed in Appendix F constructed from 1940 to 1945 that are covered under the nationwide Programmatic Agreement for World War II Temporary Buildings implemented June, 7 1986. Accordingly, the Department of the Army has met its Section 106 responsibilities for World War II Temporary Buildings. Fort Drum will not consult with SHPO or the consulting parties on management, maintenance, renovation, or demolition for any of these 305 buildings.

2. Unaccompanied Personnel Housing Program Comment

   There is one building listed in Appendix F that is covered under the ACHP Program Comments for Cold War Era Unaccompanied Personnel Housing (1946–1974), implemented August 18, 2006. Accordingly, the Department of the Army has met its Section 106 responsibilities for Unaccompanied Personal Housing. Fort Drum will not consult with SHPO or the consulting parties on management, maintenance, renovation, or demolition for this building.

3. Ammunition Storage Program Comment

   There are 12 buildings listed in Appendix F that are covered under the ACHP Program Comments for World War II and Cold War Era (1939–1974) Ammunition Storage Facilities, implemented August 18, 2006. Accordingly, the Department of the Army has met its Section 106 responsibilities for Ammunition Storage facilities. Fort Drum will not consult with SHPO or the consulting parties on management, maintenance, renovation, or demolition for any of these 12 buildings.

## V. Qualifications

Fort Drum shall ensure that all investigations performed in compliance with the terms of this PA shall be conducted by, or under the supervision of, a person who meets the Secretary of the Interior's Standards and Guidelines for professional qualifications in history, architecture, architectural history, historic architecture, or archaeology, as applicable, described in the Federal Register: June 20, 1997 (Volume 62, Number 119, pages 33707–33723).

## VI. Exemptions

A. The following areas at Fort Drum, depicted on the maps attached in Appendix G, shall be exempted from the identification requirements of this PA. These areas contain hazardous materials, including but not limited to unexploded ordinance, and are too dangerous to access for cultural resources investigations.

B. The following undertakings carried out at Fort Drum, listed in Appendix H, shall be exempted from the management requirements of this PA. These undertakings are

determined to have little or no potential to affect NRHP-eligible archaeological sites or historic buildings and structures.

C. If during implementation or construction of any of these exempted undertakings, an unanticipated discovery is made, Fort Drum shall follow the provisions for unanticipated discoveries in Stipulation VII.

**VII. Unanticipated Discoveries**

A. If a previously unknown archaeological site is discovered during an undertaking, or an unanticipated effect to a known archaeological site, historic building or structure is discovered during an undertaking, then Fort Drum shall resolve the discovery in the following manner.

   1. All disturbance of buildings, structures, or ground surfaces, as applicable, in the vicinity of the discovery shall cease and the discovery location will be secured from further harm.

   2. A qualified professional archaeologist or architect, meeting the qualification standards of Stipulation V, shall record the discovery and evaluate its nature, extent, condition, and NRHP eligibility.

   3. Fort Drum shall consult with SHPO on the eligibility of the discovery and the potential effect of continuing with the undertaking within two working days of the discovery.

   4. If Fort Drum determines that the discovery is NHRP eligible and will be further affected by the undertaking, it will consult with SHPO, and, whenever prehistoric archaeological deposits are discovered, the tribes, regarding treatment. Following consultation, Fort Drum will conduct treatment in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties; or, the Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings, as applicable.

   5. Once any field work required as part of treatment has been concluded, upon approval of the CRM, the undertaking may continue provided that all analysis, report preparation and curation, as needed, will be completed within 12 months following field work. Fort Drum will provide a copy of the discovery treatment report to the consulting parties.

**VIII. Human Remains**

A. If human remains and associated grave goods are discovered anywhere on the base, either during treatment or as an unanticipated discovery, then Fort Drum will resolve the discovery in the following manner:

   1. All work will cease at the discovery location, and the grave and its contents will be protected from further harm.

2. A professional, meeting the qualification standards of Stipulation V will record the discovery and evaluate its nature, extent, and condition.

3. If Fort Drum determines the grave is Native American, or may be Native American, it will follow the procedures outlined in the Inadvertent Discovery Agreement signed with the Oneida Indian Nation. Fort Drum will also consult with the appropriate tribe or tribes in accordance with 43 CFR Part 10, the regulations implementing the Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001 et seq.).

4. If Fort Drum determines the grave is not Native American, or the identity of the grave cannot be determined, Fort Drum will consult with SHPO pursuant to 36 CFR Part 800 to resolve the discovery. If subsequently, the remains are identified as Native American, Fort Drum will consult with the tribes pursuant to NAGPRA.

## IX. Tribal Consultation

A. Fort Drum intends to enter into separate consultation protocols with each of the tribes establishing procedures for government to government consultation on all matters of mutual concern related to historic preservation at Fort Drum. These protocols may be added to this PA through amendment under Stipulation XI. Until or unless consultation protocols with the tribes are put in place, Fort Drum will abide by the terms of this PA in consulting with the tribes.

B. In accordance with Stipulation III.D.5, Fort Drum will consult with the Oneida Indian Nation, the Onondaga Nation, the St. Regis Mohawk Tribe, and any other federally recognized tribes with an ancestral connection to the land within the base, whenever proposed undertakings may adversely affect prehistoric archaeological sites.

C. The purpose of these consultations will be to consider the views of the tribes regarding the potential effects of proposed undertakings to historic properties of religious and cultural significance to the tribes. Whenever possible, Fort Drum will work with the tribes to avoid or minimize effect to historic properties of religious and cultural significance.

D. Fort Drum has identified two prehistoric archaeological sites of religious and cultural significance to the Oneida Indian Nation, the Onondaga Nation, and the St. Regis Mohawk Tribes. The sites are the Calendar site (Site number) and the Iroquois Village site (Site Number). Fort Drum will protect and preserve these sites from future disturbance by maintaining their status as off limits to unauthorized personnel.

## X. Dispute Resolution

A. Should any signatory to this PA object to any action carried out or proposed with respect to the implementation of this PA, Fort Drum shall consult with that signatory party to resolve the objection. If Fort Drum, after initiating such consultation, determines that the objection cannot be resolved, Fort Drum shall forward documentation relevant to the objection to the

ACHP, including a proposed response to the objection, in accordance with 36 CFR Part 800.7. Within forty-five (45) days after receipt of all pertinent documentation, the ACHP shall exercise one of the following options:

1. Advise Fort Drum that the ACHP concurs in its proposed final decision, whereupon Fort Drum shall respond accordingly;

2. Provide Fort Drum with recommendations, which it shall take into account in reaching a final decision regarding its response to the objection; or

3. Notify Fort Drum that the objection will be referred to the ACHP membership for formal comment pursuant to 36 CFR §800.7(a)(4), and proceed to refer the objection and comment within forty-five (45) days. Fort Drum shall take into account the resulting comment in accordance with 36 CFR § 800.7(c)(4).

B. Should the ACHP not exercise one of the above options within forty-five (45) days after receipt of all pertinent documentation, Fort Drum may assume the ACHP's concurrence in its proposed response to its objections.

C. Fort Drum shall take into account any ACHP recommendation or comment provided in accordance with this stipulation with reference only to the subject of the objection; its responsibility to carry out all actions under this PA that are not the subject of the objection shall remain unchanged.

## XI. Amendments

Any signatory to this PA may request that it be amended, whereupon the signatory will consult with the other parties to consider such an amendment. Where there is no consensus among the signatories, the agreement will remain unchanged.

## XII. Termination

Any signatory to this agreement may revoke it upon written notification to the other parties by providing thirty (30) days notice, provided that the parties will consult during the period prior to termination to seek agreement on amendments or other actions that would avoid termination. In the event of termination, Fort Drum shall comply with 36 CFR Part 800 with regard to individual undertakings covered by this PA or with regard to all remaining actions under this PA.

## XIII. Annual Review Meeting

A. Every year, for the first five years following execution of this PA, Fort Drum will meet with the SHPO and the other consulting parties to review the performance of the PA and determine whether or not amendments are needed to improve its effectiveness. After five years, Fort Drum will meet with the SHPO and the other consulting parties every two years for as long as the PA is in effect.

B. Fort Drum may use the occasion of the annual review to report to the SHPO on the revised predictive model as required under Stipulation III.A.4.

## XIV. Management Summary

A. Every year, within 30 days of the anniversary of the signing of this agreement, Fort Drum will submit a management summary to the SHPO reporting on the activities carried out for which prior SHPO consultation was not required as provided for in Stipulations IIII.C.3, III.D.4, and IV.A.2.c. The annual report, at a minimum, will contain the following information:

1. A description of the undertaking;
2. A description of the site, building or structure;
3. The determination of eligibility;
4. The determination of effect; and
5. Any measures used to avoid or minimize effect.

## XV. Sunset Provisions

This PA shall become effective on the date it is signed and shall remain in effect for a period of 15 years whereupon it will expire unless extended by unanimous approval of the signatories or terminated.

**Signatories:**
Fort Drum
Advisory Council on Historic Preservation
New York State Historic Preservation Officer

**Concurring Parties:**
The Oneida Indian Nation
The Ondondaga Nation
St. Regis Mohawk Tribe

**Appendices:**
Appendix A: Map of New York showing vicinity of Fort Drum [not included]
Appendix B: Map of Fort Drum [not included]
Appendix C: Archaeological site definitions [not included]
Appendix D: Map of LeRay Mansion Historic District and list of contributing and noncontributing properties [not included]
Appendix E: List of historic buildings that may be National Register eligible in the future [not included]
Appendix F: List of buildings covered under ACHP Program Alternatives [not included]
Appendix G: Map of hazardous areas excluded from Section 106 requirements [not included]
Appendix H: List of undertakings exempted from Section 106 requirements [not included]

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